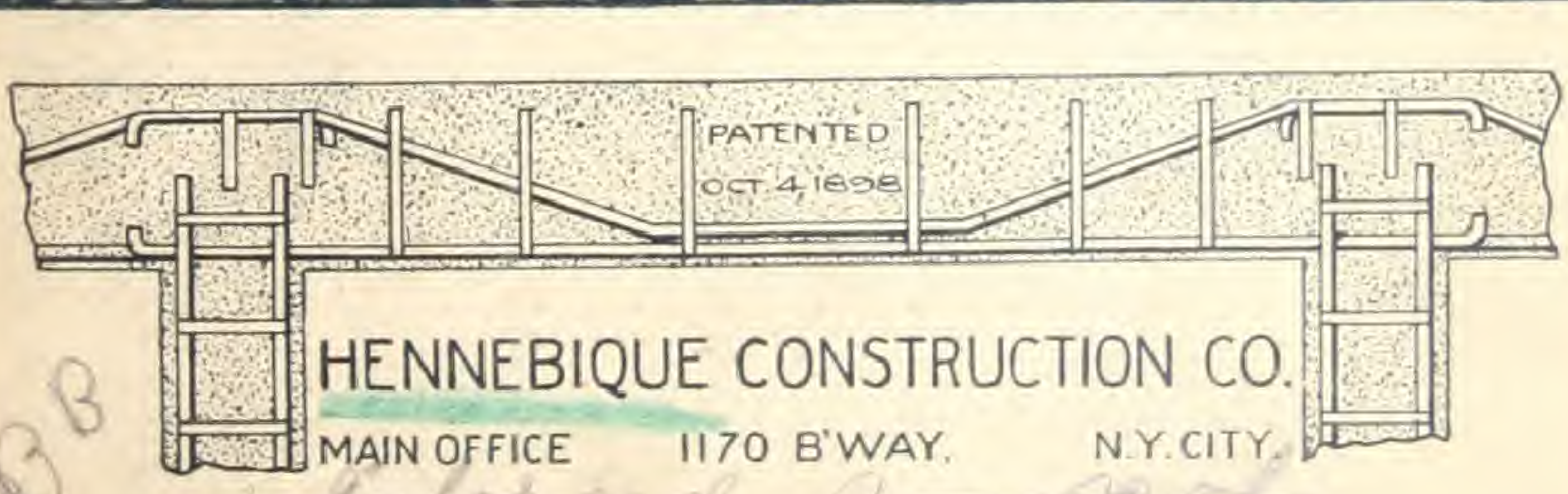
HENNEBIQUE SYSTEM



HENNEBIQUE CONSTRUCTION CO.

MAIN OFFICE 1170 B'WAY. N.Y. CITY.

Reinforced Concrete

HENNEBIQUE SYSTEM OFFICES

CENTRAL OFFICE: 1 Rue Danton, PARIS

U. S. MAIN OFFICE

1170 BROADWAY, NEW YORK CITY

:: BRANCHES ::

PHILADELPHIA, PA.,	Witherspoon Building
PITTSBURGH, PA.,	Wabash Building
NEW ORLEANS, LA.,	Hennen Building
CHICAGO, ILL.,	Monadnock Building
BUFFALO, N. Y.,	Ellicott Square
MONTREAL, CAN.,	Merchant's Chambers

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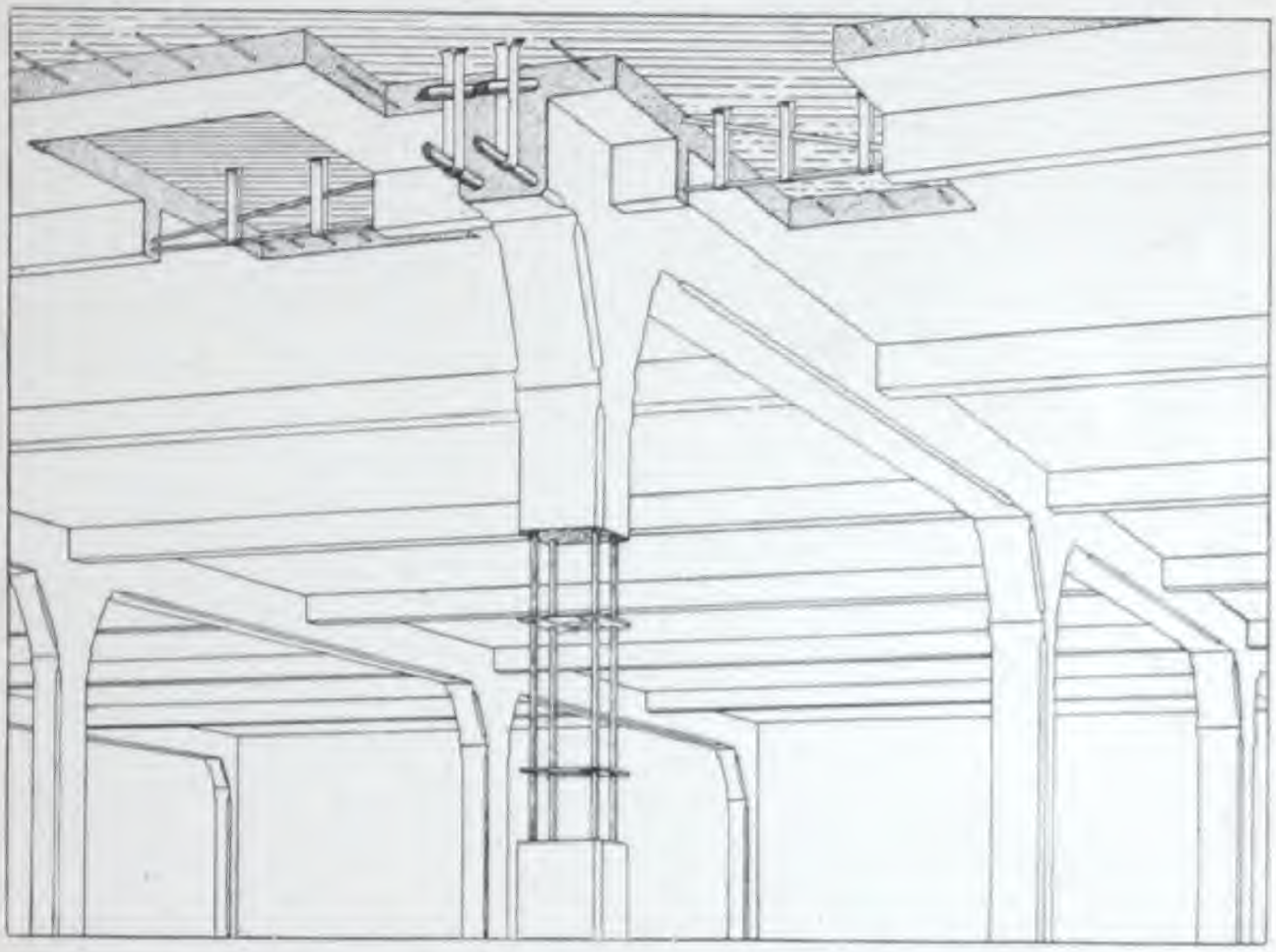
INDESTRUCTIBLE AND FIRE-PROOF

The Hennebique Armored Concrete System

PATENTED OCT. 4, 1898

Grand Prize, Paris Exposition, 1900



Hennebique Construction Company

U. S. Main Office, 1170 Broadway, New York

R. BAFFREY, General Manager

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CENTRAL OFFICE OF THE HENNEBIQUE SYSTEM OF ARMORED CONCRETE

1 RUE DANTON, PARIS — Entirely in Armored Concrete

::: INTRODUCTION :::

In presenting this fourth edition of our Typical Construction Catalog to the Building Trade, we beg to extend our heartiest thanks for the favor with which Armored Concrete has been accepted and is now considered, as we foretold five years ago, "the material of the twentieth century."

Armored Concrete, almost unknown a few years ago, has jumped into prominence as if by magic and is now being used throughout the world in nearly every class of construction. On this wonderful development we look with a feeling of just pride and satisfaction. François Hennebique, a true pioneer in the field of Reinforced Concrete, advanced in the early stages of his work, theories and principles which are largely responsible for this marvellous growth. The Hennebique System, founded upon those now standard principles and with details constantly being developed as a result of world wide experience, stands to-day proud of its past, sure of its present position, and confident of the future.

Incident to this rapid growth many engineers and contractors have rushed into reinforced concrete work with no practical experience behind them. In Reinforced Concrete, more than in any other class of construction, the personality of the designer and builder is all important. The best design is apt to result in a weak structure in the hands of an inexperienced builder. On the other hand, no contractor, however competent, can erect a first class reinforced concrete structure from a poor design. There is no standard set of formulæ which can be universally applied. The details of construction, which come only by experience, prove often of greater importance to the strength of a structure than the stresses allowed in the concrete and steel.

Great harm is being done the Reinforced Concrete Trade by those Consulting Engineers who, even after thorough study of the subject and inspection of a few buildings in the course of erection, but with little or no real experience in this class of work, pose as Experts in Reinforced Concrete, and undertake the design and superintendence of buildings. Equal harm results from the sending out of detailed plans and instructions by patented bar "can't make a mistake" systems to inexperienced local contractors throughout the country and leaving these builders in full charge of the work.

We cannot too strongly condemn these two practices which often lead to weak structures and even failures.

We thank the business men or laymen for the rapid advancement of an economical and durable building material and it is to these men, their Architects and Associated Engineers that we present this book with samples of our handicraft and freely place at their disposal our advice in Reinforced Concrete.

We will not give any tables and theoretical methods of designing as is so often done in hand books, because we believe that such practice has been an element of failure, due to superficial acceptance of such tables and ignorant use of the formulæ. We wish to be entirely responsible for any use made of our information.

We are Consulting Engineers and Contractors, backed by twelve years' experience and with references of over Twenty-two thousand buildings, amount-

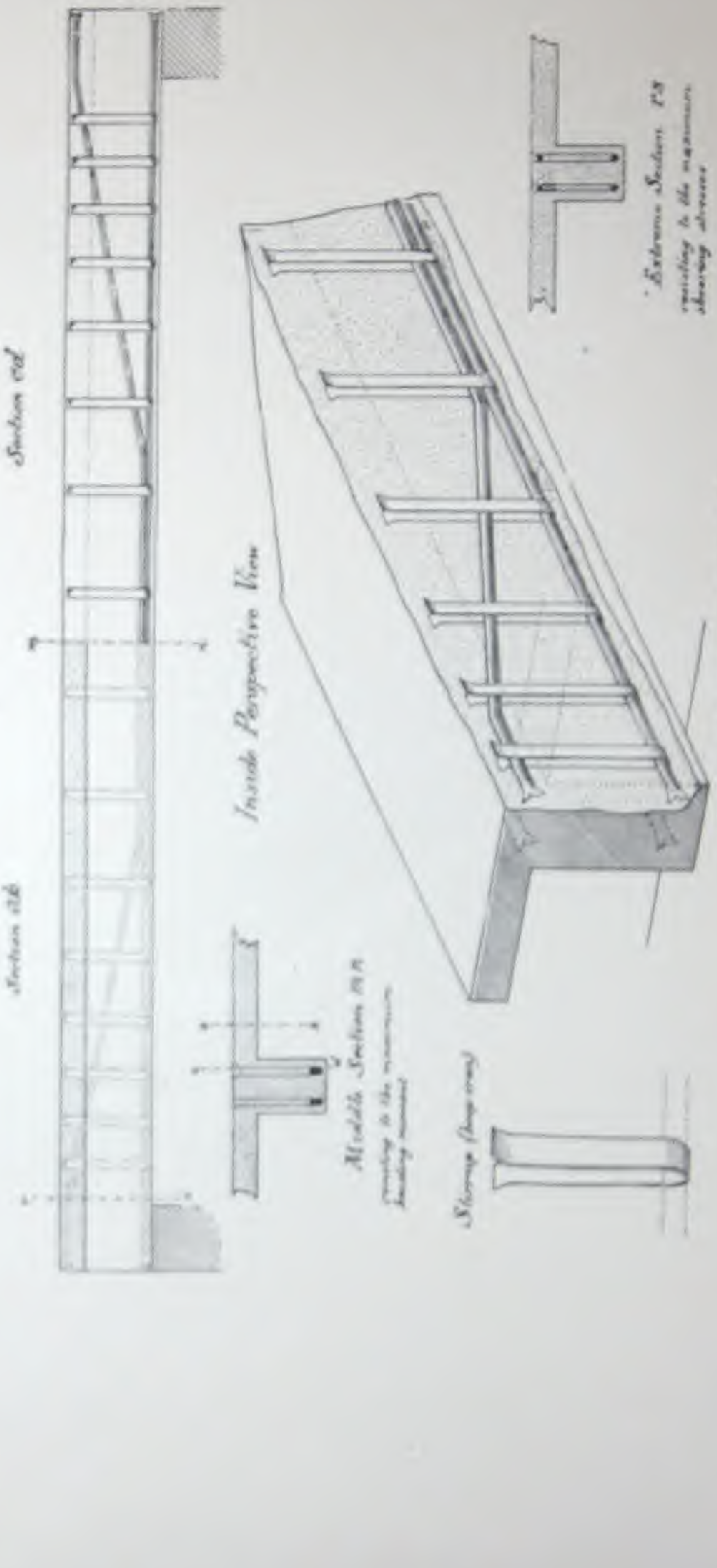


Fig. 1. TYPICAL HENNEBIQUE BEAM

ing to more than *One Hundred Million* dollars' worth of Armored Concrete, all erected under our supervision according to the

HENNEBIQUE SYSTEM

considered by many the

STANDARD OF THE WORLD.

This system controls more than fifty organized offices and four hundred licensed contractors. The resources of these are enormous and are at the disposal of our clients. The following cuts show what we have done and what we can do in designing and erecting.

HISTORICAL.

While Concrete was known for centuries as a durable building material, it was only by imbedding in its mass the necessary amount of steel at the required place to take up the tensile and shearing stresses, and thus adding tensile strength to its compressive qualities that it was possible to use it extensively as a building material.

The combination of steel and concrete gives the compressive strength of the masonry construction and the possibility to resist bending of the steel construction. It has not the imperfection of the joint or masonry nor that of corrosion, as found in steel structures.

The first attempt to use concrete and steel together did not have even this purpose, but was merely to cover a steel wire netting by concrete. Thus a boat was built by Lambol de Minoval in 1849, flower boxes, water tanks and later on, floor slabs were constructed by the gardener Monier, in 1867.

HENNEBIQUE SYSTEM OF ARMORED CONCRETE.

It remained, however, for Hennebique to adapt the principles of Armored Concrete to structures and to invent a rational kind of reinforcement for beams

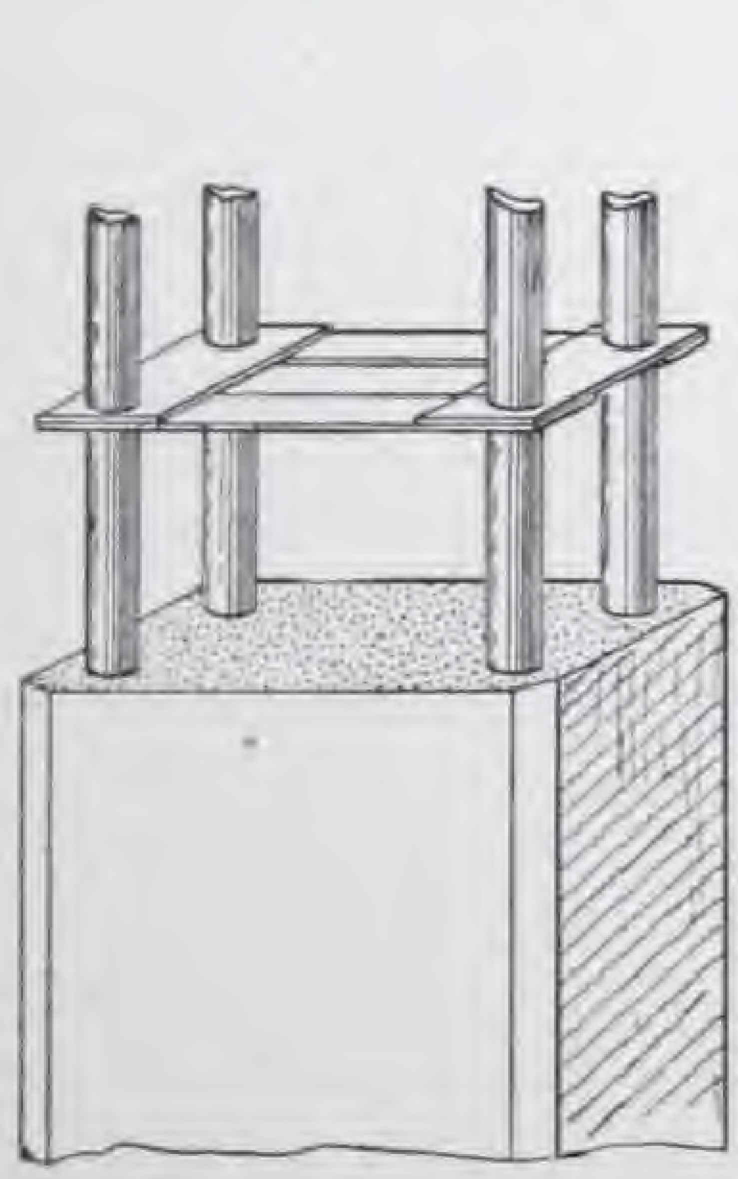


Fig. 2. COLUMN

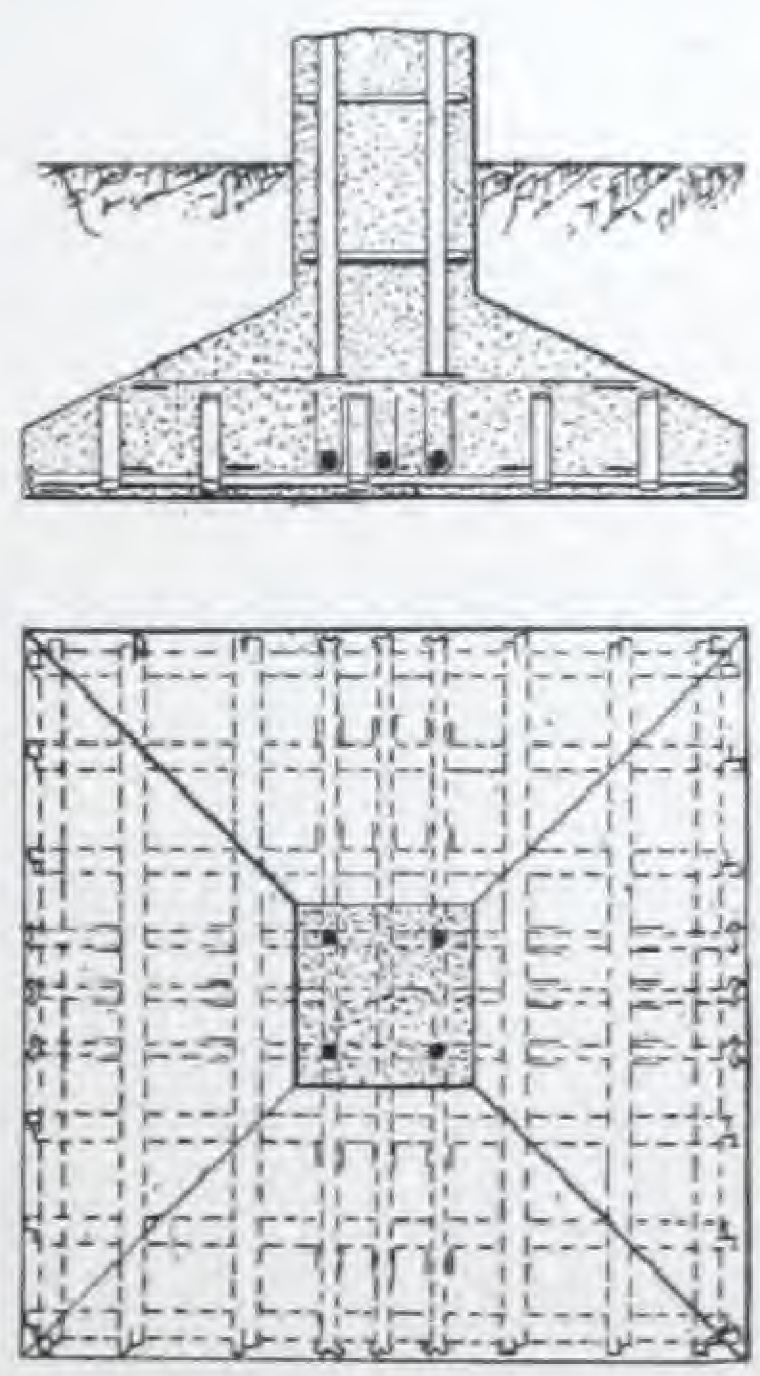


Fig. 3. COLUMN FOOTING

and columns. After several years of tedious and extensive tests, he patented and put on the market a system of construction of Armored Concrete in which the armature of the beams was formed by steel bars placed at the lower flange, where the tensile stresses occur, and by vertically placed stirrups embracing the steel tension bars, and intended to take the vertical and horizontal shear developed in the beams.

Thus a rational reinforced concrete beam was formed, the concrete taking care of all the compressive stresses, the steel taking care of the tensile and shearing stresses.

The armature of the columns was designed according to the same principles and the steel rods were embedded near the corners and tied together at close intervals by means of hoop steel ties or collars, (Fig. 2).

THE INVENTION OF THE BENT ROD

These two elements of construction permitted Hennebique to erect buildings entirely in Armored Concrete and soon after having convinced himself that the most essential quality of Armored Concrete structures was their monolithicity and that the constituting elements should be continuous, he invented the bent bar and thus designed more economical and stronger beams and girders.

That date is an epoch in Reinforced Concrete Construction. From that day it was possible to erect safely and economically, important Reinforced Concrete structures in which the elements, steel and concrete, were of such an amount and placed in such a way as to take care of the compressive, tensile and shearing stresses which are developed in structures, and all this in such a way that each material worked with its utmost efficiency and economy.

Hennebique patented this new form of construction and has since obtained numerous patents in all civilized countries. We may mention among them the following, granted in the United States:

HENNEBIQUE PATENTS

611,907 issued............................Oct. 4, 1898
611,908 issued............................Oct. 4, 1898
611,909 issued............................Oct. 4, 1898
707,924 issued............................Aug. 26, 1902

The extreme simplicity and economy of the Hennebique System and the rational arrangements of its component parts, must be at once apparent to even a casual observer. The concrete, which acts as the embedding medium, takes only compressive stresses, while steel rods and stirrups are placed wherever tensile and shearing stresses occur.

FLOOR BEDS

The Hennebique floor beds are of two kinds, flat and arched, as shown by Figs. 4 and 5.

Fig. 4. FLAT FLOOR CONSTRUCTION

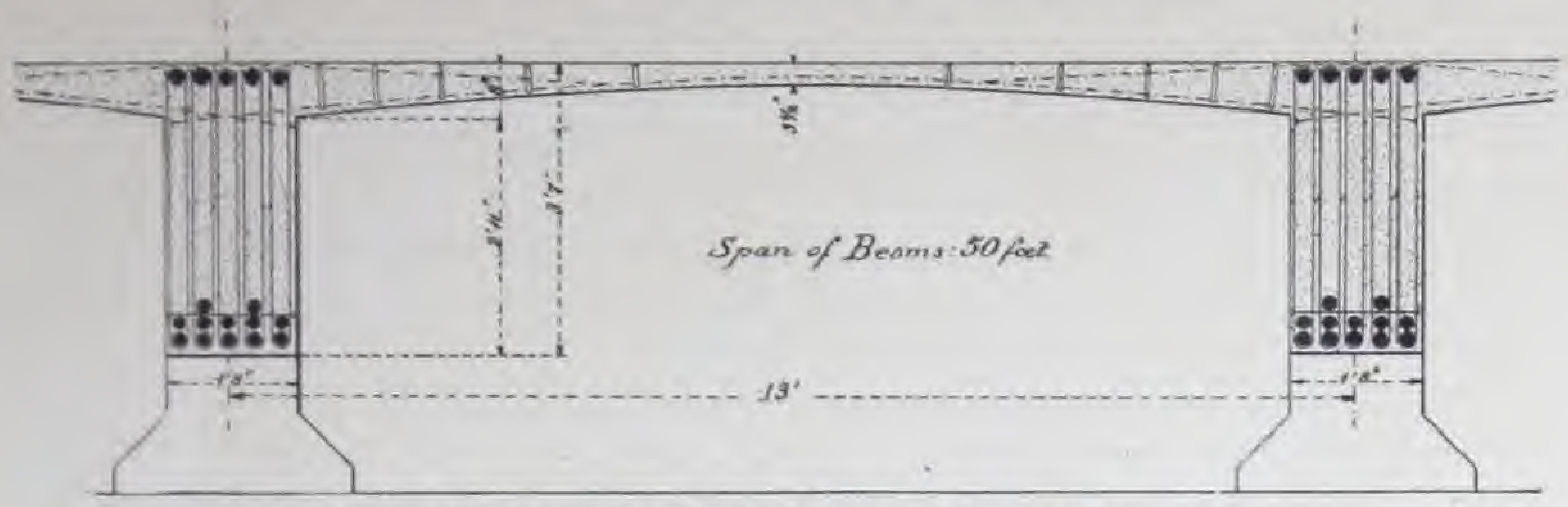


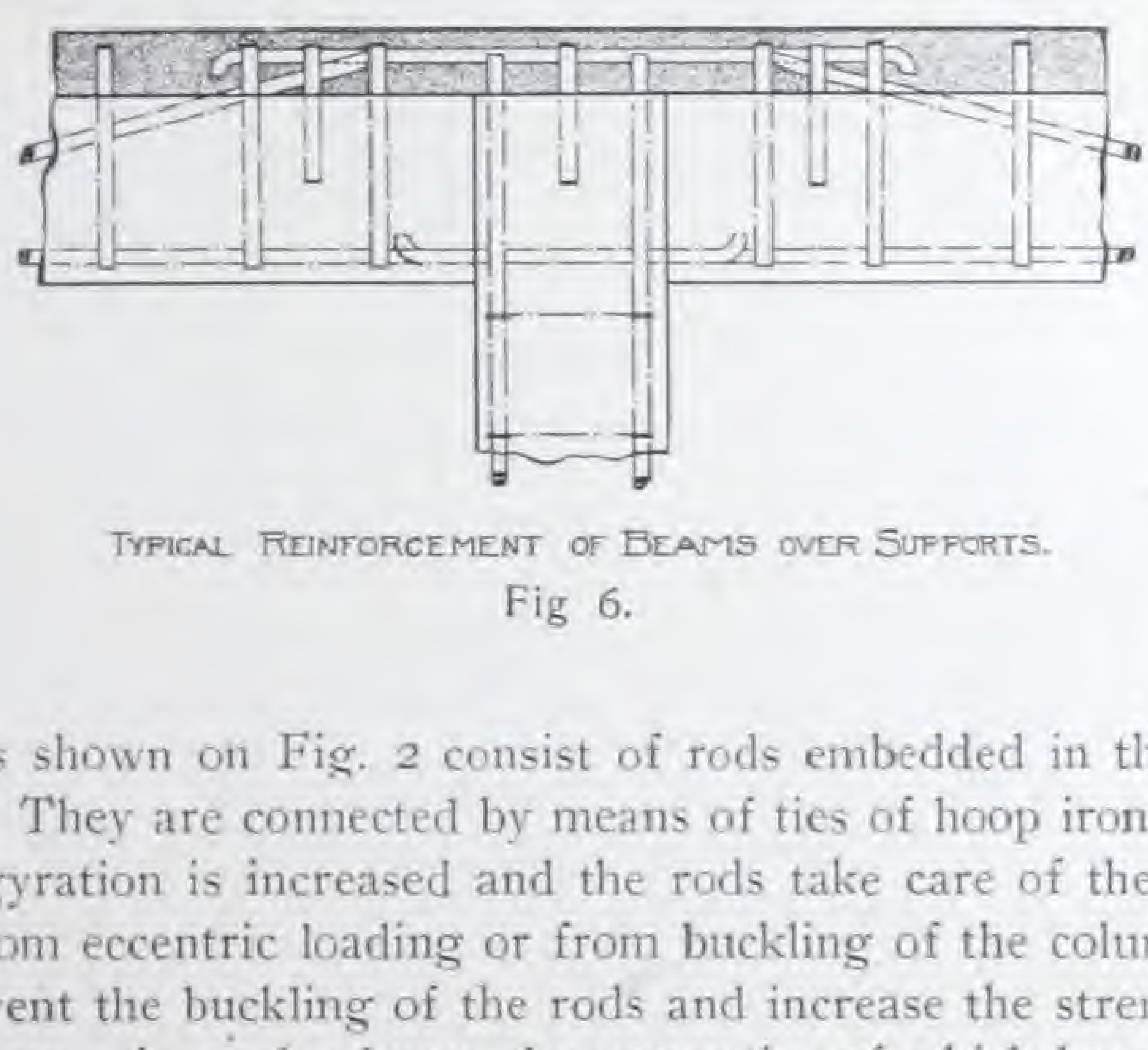
Fig. 5. ARCHED FLOOR CONSTRUCTION.

Both types are well suited to long spans. The small rise of the arched construction gives a very light appearance and is adapted to the ceilings of crypts, etc.

BEAMS

In the Hennebique Beam (Fig. 1) the concrete is relied upon to resist the compressive stresses in the upper part of the beam, while the steel rods resist all tensile stresses in the lower portion. The concrete also forms the connection between the two flanges, assisted by the stirrups, generally formed of hoop steel. These are of great importance in the Hennebique System, and besides acting as a connection between the upper and lower parts of the beam, take also the horizontal shear. For this reason the stirrups are placed closer together near the supports.

The rods in a beam are of two kinds—straight and bent. The bent rods, besides taking their proportions of the direct tension and of the shear, take any tensile stresses in the upper portion due to a negative moment over the support. (Fig. 6). A beam of this description is similar in many respects to a timber trussed with steel tie rods and brackets.



TYPICAL REINFORCEMENT OF BEAMS OVER SUPPORTS.
Fig 6.

COLUMNS

Columns shown on Fig. 2 consist of rods embedded in the concrete near the periphery. They are connected by means of ties of hoop iron or wire. Thus the radius of gyration is increased and the rods take care of the tensile stresses which occur from eccentric loading or from buckling of the columns. The horizontal ties prevent the buckling of the rods and increase the strength of the concrete. They form a hooped column, the properties of which have been so clearly explained by M. Considere.

FOOTINGS OF COLUMNS

Footings of columns as shown on Fig. 3 are also of a very simple construction. Steel rods, scientifically placed, form with the concrete a flat plate which distributes the load equally over the soil. One can readily see how cheap such a foundation is. It replaces the Chicago system by which "I" beams are embedded in concrete, and it avoids the waste of material of both steel and concrete, which is enormous in other systems.

PILES

Hennebique Piles (Figs. 7 and 8) are similar in construction to the Hennebique columns. The point, however, is protected by a cast iron or sheet metal shoe. In the sheet piles the point is formed by beveling one of the narrow faces so as to form a wedge with the opposite face, and both narrow faces are slotted by a semi-circular groove running from point to butt. The semi-circular grooves form, when the piles are driven as a sheeting, a circular hole from top to bottom between each pair of piles. This hole serves for a water jet during driving, and when finally filled with cement the whole forms a monolithic sheet of piling. The Hennebique Piles are driven by a drop hammer in the same manner as wooden piles; the top of the pile is, however, protracted by a false pile or cap, which serves to lessen and distribute the shock.

SHEET PILES

WALLS

Armored Concrete walls may be built either solid or hollow. They are armored by steel rods, vertically and horizontally. By these the tensile stresses caused by buckling are taken up. A wall of this kind, for a given load requires only about one-third the thickness of a corresponding brick wall, thus saving a considerable amount of floor space.

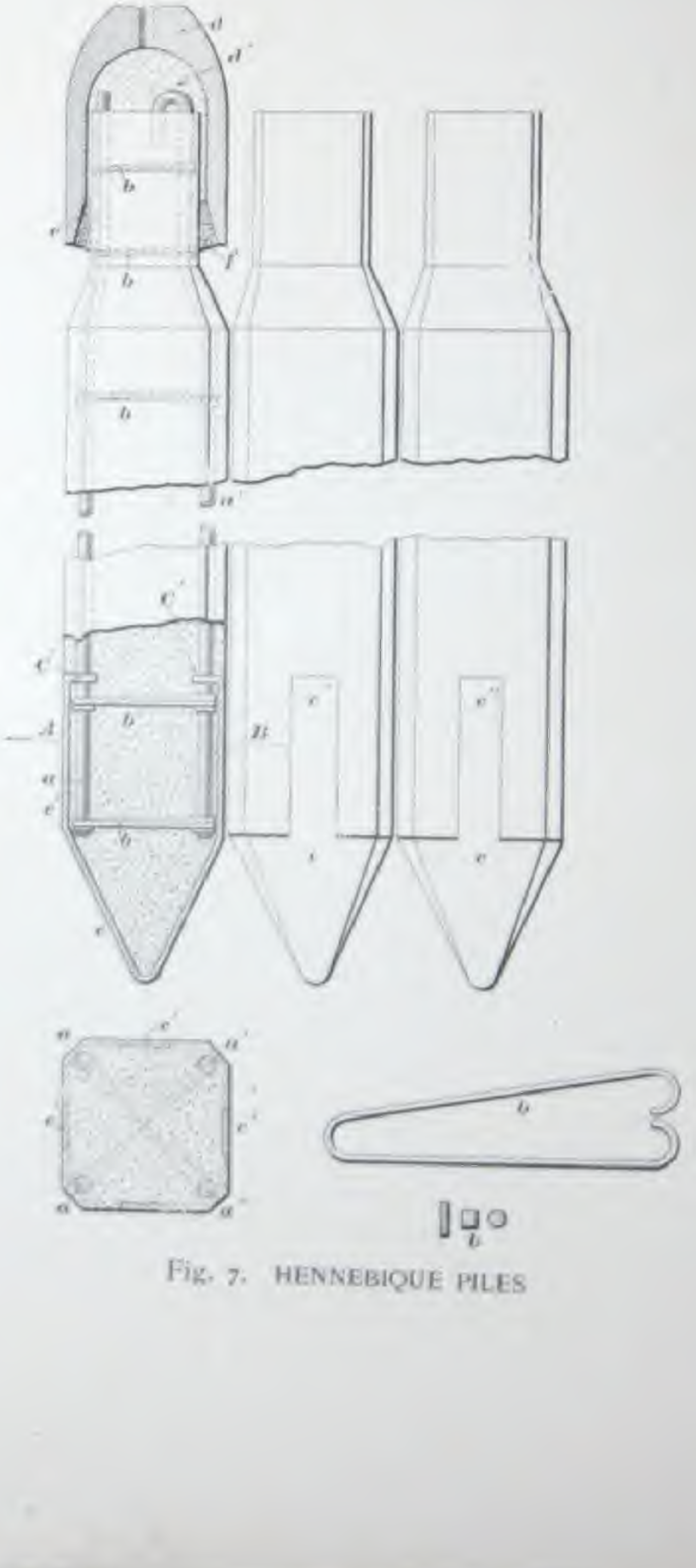


Fig. 7. HENNEBIQUE PILES

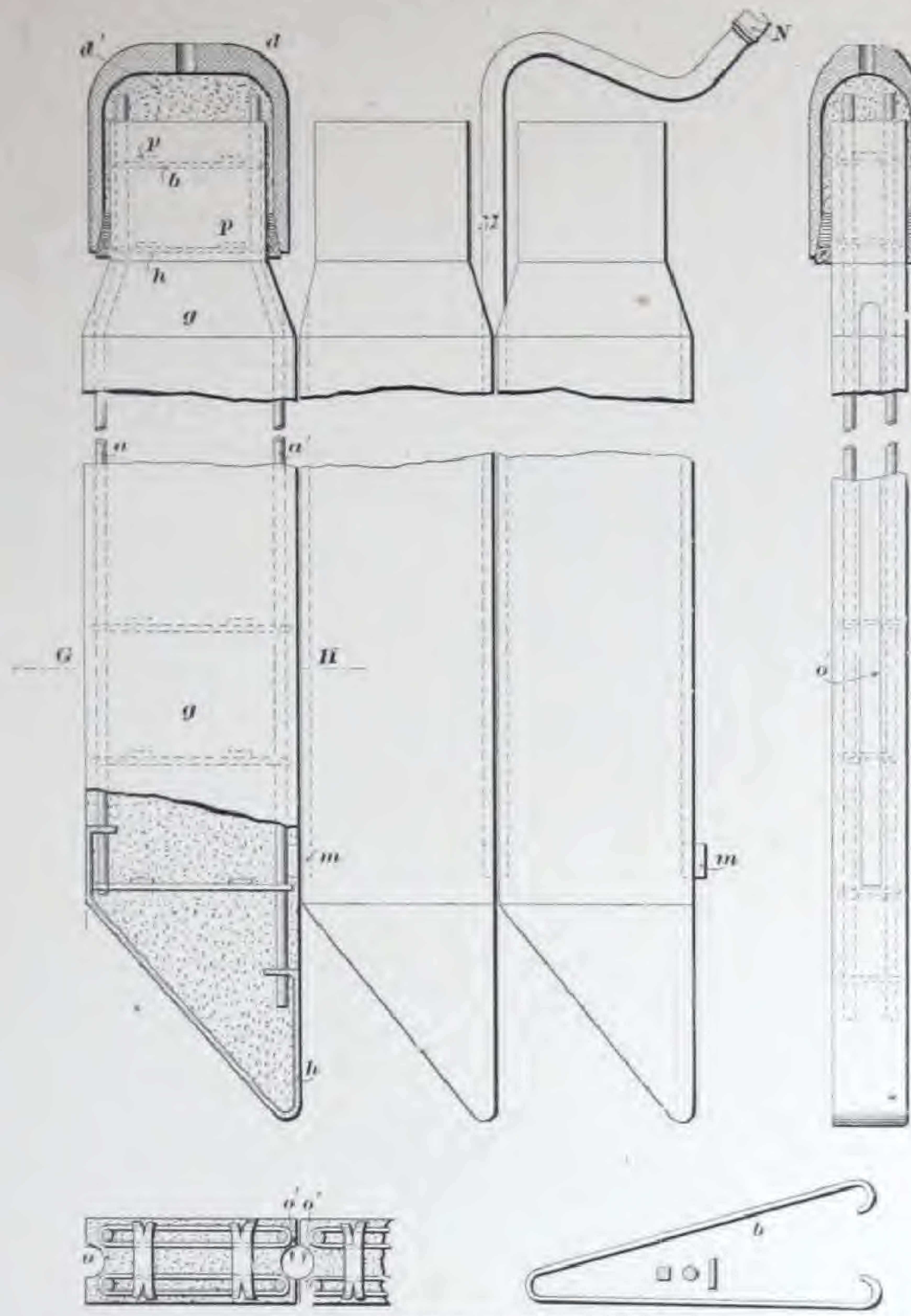


Fig. 8. HENNEBIQUE SHEET PILES

QUALITIES OF ARMORED CONCRETE.

The designing of all Hennebique structures is governed by the following assumptions:

1st.—Tensile stress in concrete is not to be considered.

2nd.—Concrete and steel have practically the same co-efficient of expansion.

3rd.—The adhesion between steel and concrete is greater than, and therefore determined by, the shearing value of concrete.

Many patented bar concerns imagine that by providing a slight mechanical bond, they may use any size rod and yet develop its full tensional stress.

The deforming of bars and twisting of square and flat bars merely increases by a small percentage the effective shear area. In the Hennebique System, rods are always selected of such diameter that they will fail by tension rather than by shearing of the concrete.

Among the principal advantages of the Hennebique System of Armored Concrete may be mentioned the following:

Ability to resist fire.	Hygiene and cleanliness.
Indestructibility.	Decorative qualities.
Simplicity of construction.	Economy.
	Adaptability.

FIRE RESISTING QUALITIES.

Armored Concrete, from the very nature of its construction, is fireproof. The perishable material, steel, is so embedded in the concrete that it is impossible for it to be affected. Tests have repeatedly shown this, and the Hennebique System has been approved by the building departments in the principal cities of the United States and Europe as a first class fireproof material for floors, beams, columns and walls.

(The Building Department of New York City approved Armored Concrete as a fireproof material.)

It is known that the New York City authorities specify very severe tests, to which all fireproof materials must be subjected before being allowed to be used in fireproof buildings. Section No. 106 of the New York City Building Code reads as follows in reference to this test:

NEW YORK BUILDING DEPARTMENT FIRE-PROOF TEST

"And subjecting the platform so constructed (of material to be tested) to the continuous heat of a wood fire, averaging not less than seventeen hundred degrees Fahrenheit for not less than four hours during which time the platform shall have remained in such condition that no flame will have passed through the platform or any part of same, and that no part of the load shall have fallen through, and that the beams shall have been protected from the heat to the extent that after applying to the under side of the platform at the end of the heat test, a stream of water directed against the bottom of the platform and discharged through a one and one-eighth inch nozzle under sixty pounds pressure for five minutes, and after flooding the top of the platform with water under low pressure and then again applying the stream of water through the nozzle under sixty pounds pressure to the bottom of the platform for five minutes, and after a total load of six hundred pounds per square foot uniformly distributed over the middle bay shall have been applied and removed after the platform shall have cooled, the maximum deflection of the interior beams shall not exceed two and one-half inches."

Our construction stood this test very successfully, as is shown by the following letter from the New York City Building Department approving the Hennebique System of Reinforced Concrete:

THE BUREAU OF BUILDINGS, CITY OF NEW YORK,

Aug. 10, 1904.

MR. R. BAFFREY, PRES. HENNEBIQUE CONSTRUCTION COMPANY, NEW YORK, N. Y.

DEAR SIR: As a result of the fire and water test on July 20, 1904, under the supervision of this Bureau, your form of concrete-steel construction, known as the HENNEBIQUE SYSTEM, is approved for use in the Borough of Manhattan as a fireproof construction, on the following conditions:

HENNEBIQUE SYSTEM ACCEPTED BY THE NEW YORK BUILDING DEPARTMENT

Such constructions will be made in accordance with the rules and regulations of this Bureau regarding the concrete-steel construction; the strength of such construction shall be determined in accordance with the above mentioned rules and regulations.

The concrete used shall consist of one part Portland cement, two parts sand and four parts trap rock. A slag concrete may be substituted for trap rock, provided the tests which are still to be made show that the concrete meets with the requirements of Section 5 of the Rules; the ratio of the moduli of elasticity of the slag concrete and the steel shall be fixed in accordance with the results of these tests.

All steel used in the construction shall be surrounded on all sides with at least three-quarters of an inch of concrete; no column used in this construction shall be less than eight inches square; the minimum thickness of slabs in floor construction shall be three and one-

half inches; your company shall be responsible for the proper installation of such constructions and full compliance with the rules and regulations mentioned above.

Very truly yours,

(Signed) ISAAC A. HOPPER,
Supt. of Buildings, Borough of Manhattan.

Not only in especially prepared tests has the Hennebique System shown its high fire resisting qualities, but this has been fully demonstrated also in every conflagration to which Hennebique buildings have been subjected.

Such buildings not only stood the fire, but the structures were not weakened, and they were again used as originally erected.

BALTIMORE FIRE

A most striking example is the United States Fidelity & Guaranty Building, Baltimore, Md., which withstood the Baltimore fire of February, 1904.

This building was a five story structure, 20′ front and 67′ deep, of the skeleton style, and was surrounded by brick walls, which, under the intense heat, disintegrated and collapsed, as shown in the accompanying cut. The front wall fell outward, leaving the floor hanging free as a cantilever. The floor slabs were of arch construction, having a thickness of 4″ at the crown and 6″ at the springing line, and a span of 10′ 6″. The intense heat, which melted the metal parts of the typewriters in the building, did not do the slightest damage to the floors. At some places, the edges of the beams spalled off, but the strength was not at all affected, as the test (a description of which we give) made a few days afterwards shows.

Fig. 9. UNITED STATES FIDELITY & GUARANTY COMPANY BUILDING
Through the intense heat the brick walls collapsed, leaving the armored concrete skeleton free and uninjured

TEST OF HENNEBIQUE FLOORS AFTER THE FIRE

In order to ascertain if the floors (constructed in the Hennebique System) which withstood the fire, were affected by the intense heat, a test was made on March 10th, 1904, with a superimposed load of twice the load for which the floors were designed.

A girder and the floor area, supported by the girder, was loaded with brick as shown on the sketch.

The aggregate load, amounting to an average of three hundred (300) pounds per square foot, caused a deflection of only ⅛ of an inch, equal to 1-2000 of the span.

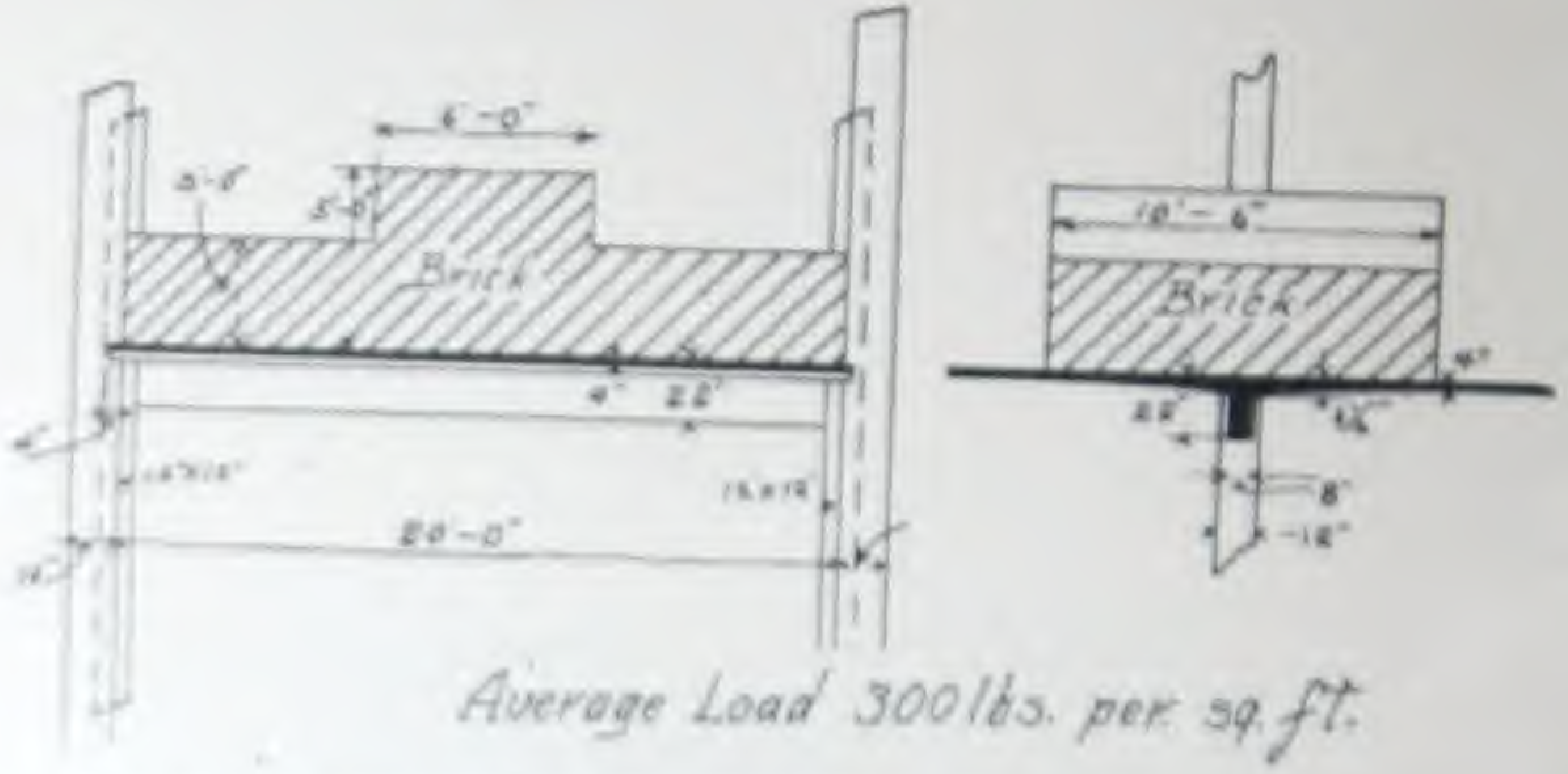


Fig. 10. TEST ON UNITED STATES FIDELITY & GUARANTY COMPANY BUILDING
Floors under twice the superimposed load the deflection is but ⅛ of an inch

The test was witnessed by many prominent architects, builders and others, among whom were Capt. John S. Sewell, of the U. S. Engineers' Corps; W. F. Stewart, Assistant Engineer, B. & O. R. R. Co.; Douglas H. Thomas, Jr., of Parker & Thomas; John Waters, Builder; Paul Emmart, Architect; City Engineer Fendall and Water Engineer Quick.

OPINIONS OF BUILDING EXPERTS

All building experts were impressed by the fact that the concrete structure stood the fire better than those of steel protected by hollow tile. We may mention what Mr. Washington Hull, the well-known Architect, stated in the Baltimore American of Feb. 21, 1904, as follows:

"Outside iron shutters have been shown to be practically without value for such a fire. I have come to the conclusion that *Concrete stood the fire much better than terra cotta*, which crumbled into dust in many cases under the heat. *At the United States Fidelity & Guaranty Building, where concrete floors connected with concrete columns, covering iron rods were placed inside of the old brick walls, I found it in excellent condition.* The old brick walls have bulged out, leaving the *concrete standing intact*, the floors like a table top set upon legs formed by concrete columns."

Professor Ira H. Woolson, of Columbia University, in the "Baltimore Sun" of Feb. 1, 1904, stated as follows:

"The metal protection in the hollow tile floors was not so good as it should have been. What protection there was amounted to about one inch of material—not enough. *We saw only two buildings with reinforced concrete construction, and both were in excellent condition.*

INDESTRUCTIBILITY.

Concrete, among the materials used by the ancients, is the one which has best withstood the action of time. It is also the best preservative of steel in use to-day. We have, therefore, in Armored Concrete an ideal combination of materials for Indestructibility.

NO CORROSION OF STEEL BARS POSSIBLE

In order to produce rust three elements are necessary, water, oxygen and acid. Portland Cement, through its alkaline composition, neutralizes the small amount of acid which is always in the air or water everywhere in contact with concrete structures, and thus prevents the formation of rust. Furthermore, rust itself is absorbed by Portland Cement concrete and forms a special combination of greater strength than Portland Concrete. It has been shown many times that a rusted iron rod imbedded in concrete was cleaned of its rust after a stay of a few weeks in this material. The concrete next to the rod was found to be of greater strength than the other, and its adhesion to the steel was such that it was difficult to cut it off with a chisel.

As a consequence of this property it is recommended that in Armored Concrete structures rods covered with a small amount of rust shall be used in preference to clean ones.

It is through this property that Armored Concrete can be safely used in water works, such as making pipes, concrete piles, sea walls, etc.

In tearing down old armored concrete structures this remarkable property of the protection of steel has been fully demonstrated. We may especially refer to a concrete steel pipe built in 1886 in the city of Grenoble, France, which was removed in the presence of many Engineers in 1901. Following is the report:

The city authorities had laid in 1886 a line of armored concrete water papes 330 ft. in length.

ARMORED CONCRETE PIPE IMBEDDED 15 YEARS WITH NO SIGN OF RUST

The pipes have at all times resisted and still resist the normal pressure of 80 ft. head of water. The length of each section of pipe is 6 ft. 3 in.; its thickness 1⅜ ins., and its internal diameter 12 ins.

The metal skeleton of these pipes is formed by thirty longitudinal rods ¼ in. diameter and by an internal 5-32 in. spiral wire; also an external ¼ in. spiral wire.

The sections of the pipes weigh 88 lbs. each. They are connected together with Armored Concrete rings.

On the 22d of February, 1901, a length of 16 ft. of these pipes was raised. Two of the joint rings were broken so as to set free two lengths of pipe which had been laying under 3 ft. of ballast.

A close examination of these pieces establish the following facts:

1st.—The irreproachable state of preservation of the pipes, in which there was found a slight calcareous deposit about 1-16 in. thick. They do not show the least fissure, either internally or externally.

2nd.—There exists no trace of oxidation from the metal. The binding in wire which connects the longitudinal rods is absolutely free from oxidation.

3rd.—The adherence between the metal and the cement concrete constituting the body of the pipe was such that, despite the thinness of the concrete (1⅜ ins.), they could only be separated by heavy blows from a sledge hammer.

4th—When struck with the hammer these pipes evinced remarkable sonority, such as might be obtained from a sound cast-iron pipe.

5th.—The detached fragments of the cement concrete showed very sharp angles.

6th.—The Water Committee of the City Council declared that this line of pipes had required no repairs since it was set in place in 1886.

GREAT STRENGTH AND STIFFNESS.

The great strength and stiffness of Armored Concrete is one of its greatest advantages. This strength and stiffness increases with age.

As Armored Concrete has neither joints, rivets nor bolts, and is moulded into a monolithic structure, forces applied to any one part will be resisted by the entire structure and the strain on each particular element greatly reduced.

Another result of this unity is to greatly decrease the vibration of Armored Concrete constructions under shocks and moving loads.

VIBRATION TESTS

Accurate tests made by Mr. Lanna, Chief Engineer of the Orleans Railroad Company, Paris, have shown the differences between the vibrations of steel beam floors and of Armored Concrete floors. The floors tested had each a span of 16 feet, and carried a machinery load of 280 pounds per square foot. A weight of 110 pounds falling from a height of 6′ 10″ on a steel beam floor produced vibrations of an amplitude of 5-32 of an inch, lasting two seconds, while a weight of 220 pounds falling from a height of 18′ 10″ on the Hennebique floor produced vibrations of an amplitude of 1-32 of an inch, lasting only 5-7 of a second.

The following diagram (Fig. 11), obtained with a deflection registering apparatus, shows plainly the result of the test.

Comparative results of vibrations produced by falling weights on a steel beam floor and on an Armored Concrete floor:

PARIS-ORLEANS RAILROAD COMPANY.

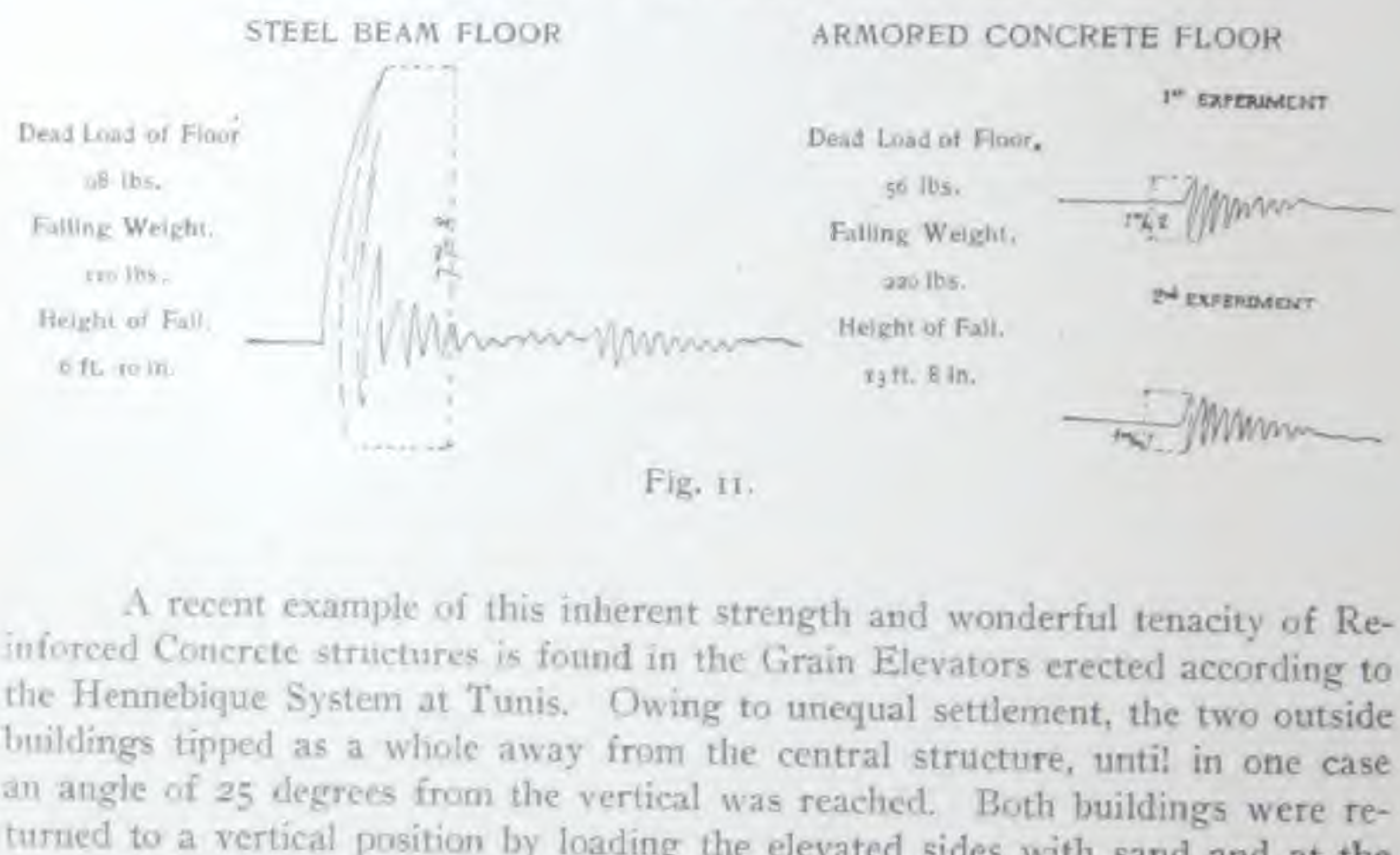


Fig. 11.

WAREHOUSES AT TUNIS

A recent example of this inherent strength and wonderful tenacity of Reinforced Concrete structures is found in the Grain Elevators erected according to the Hennebique System at Tunis. Owing to unequal settlement, the two outside buildings tipped as a whole away from the central structure, until in one case an angle of 25 degrees from the vertical was reached. Both buildings were returned to a vertical position by loading the elevated sides with sand and at the same time making excavations along the foundations on the same side. Throughout this severe test the buildings remained whole and intact.

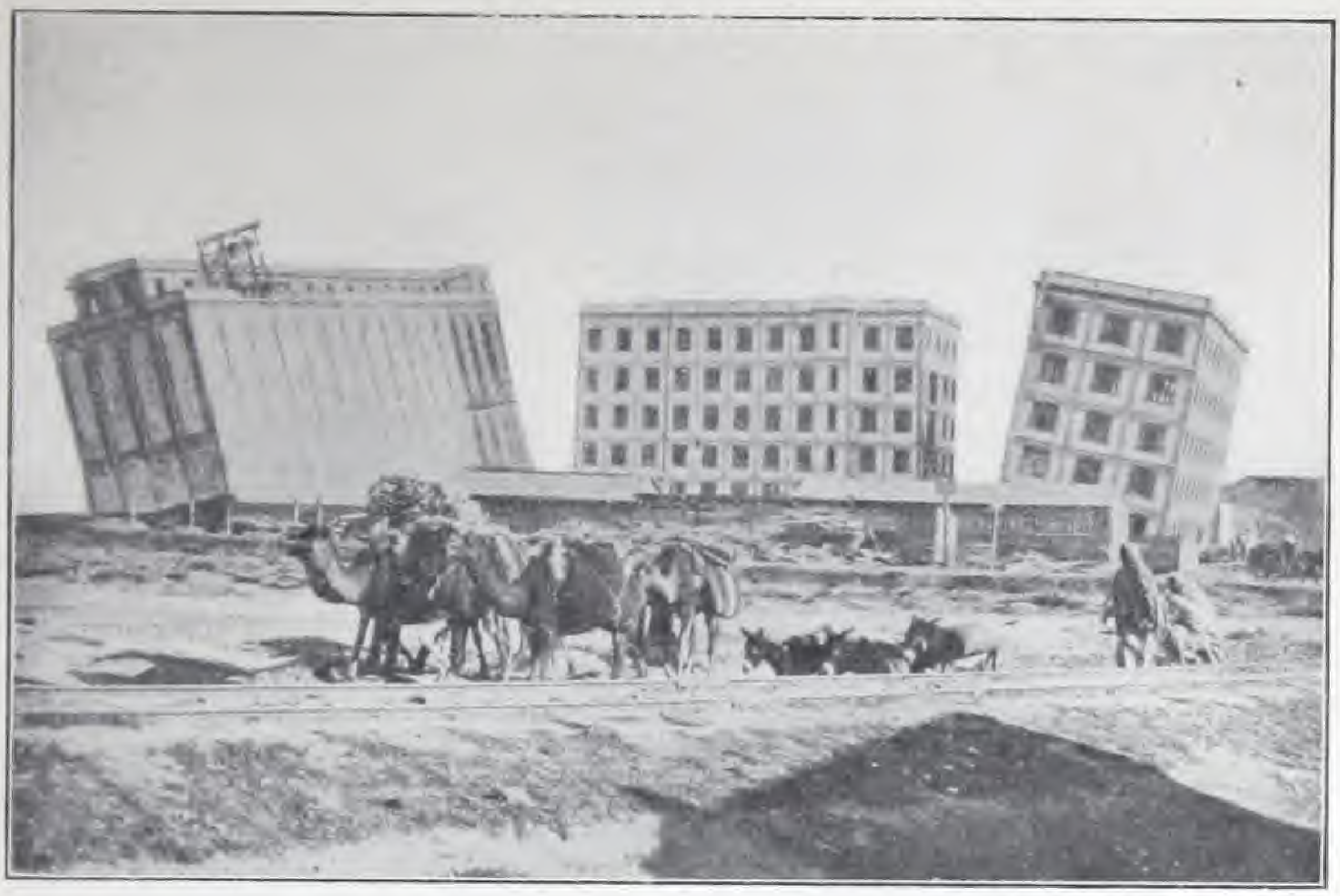


Fig. 12. GRAIN WAREHOUSES, TUNIS

Fig. 13. GRAIN WAREHOUSES, TUNIS

Interior view of one of the inclined buildings, showing the method used in bringing them to a vertical position. The plumb line at the left conveys some idea of the extent to which the building topped.

SIMPLICITY OF CONSTRUCTION.

Armored Concrete is being used extensively all over the world, even in the remotest colonies. This is due entirely to its simplicity and to the possibilites of the work being done by native workmen. However, no money should be spared to have the work in charge of a good Superintendent, one who understands how to mix and place concrete, arrange the reinforcement and erect the forms. In general, a superintendent, a few carpenters and a head concrete man will form the nucleus of an organization, the balance of the help being the local workmen.

MATERIALS EASILY OBTAINED

Materials, also, can generally be obtained right on the job. The materials to be shipped, such as steel and cement, are not of such large amounts, and can be hauled at a small cost. In any locality, suitable aggregates (sand, gravel and stone) can be obtained.

PROTECTION AGAINST RODENTS

Considered from a hygienic point of view, this process offers the advantage of absence of porosity inseparable from the present ordinary modes of building. It does not afford any shelter to rodents; they cannot attack Armored Concrete. This property is greatly appreciated in Flour Mills, Grain Warehouses, etc.

VALUE IN HOSPITALS AND SCHOOLS

Armored Concrete can be easily and thoroughly cleaned, a property of great value in Hospitals, Schools, Barracks, etc.

Jail Cells and Banking Vaults have been constructed in the Hennebique System of Armored Concrete, and even bullet-proof screens for target practice.

It may be noted here that several great Powers are now using Armored Concrete for the protection of fortresses against fire shell.

ECONOMY.

The cost of the Hennebique System of Armored Concrete ranges between that of mill construction and steel skeleton fireproof construction. Considering the item of insurance, however, Armored Concrete becomes more economical than the apparently cheaper mill construction.

SAVING IN INSURANCE RATES MAKES ARMORED CONCRETE CHEAPER THAN SLOW BURNING STRUCTURES

In the item of insurance alone the saving on premiums for three or four years would more than make up the increased cost of Armored Concrete over the other non-fire systems. Take, for example, a Warehouse which would cost say $100,000, and in which merchandise to the amount of $200,000 would be stored. The insurance premiums for mill construction at the rate of $1.40 per hundred would amount annually to $4,900.00. If built in the Hennebique System the premiums would be at the rate of 35 cts. per hundred, or $1,050 per annum, an annual saving of $3,150.00, equal to 3.15% of the investment.

As Hennebique structures are but 10% to 15% more expensive than non-fireproof constructions, in three or four years the increase in cost of the building will have been saved by the reduction in insurance premiums.

INCREASE OF RENTING SPACE IN ARMORED CONCRETE BUILDINGS

In replacing structural steel or masonry by Armored Concrete, a reduction in the thickness of the walls and floors of structures is possible. Where a twenty-four inch brick wall is required a seven or eight inch concrete wall will replace it. The dead space is considerably reduced and the renting space of the building is consequently increased. If we take an ordinary office building in which seven inch walls are used instead of brick walls, the increase of renting space would be about 15% per floor. By using an Armored Concrete floor the thickness of the floor is also reduced and this permits a saving of space in the total height of the building.

We often use five inch slabs for long spans where steel and fireproofing would require a fourteen inch thickness of floor. This causes a saving of nine inches for each floor or ten feet six inches on a fourteen story building, thus saving an entire story in the height, a gain of 14%.

The use of Armored Concrete makes it possible, in New York, to construct an eight story tenement house of the same height as a seven story building if other materials are used.

The small dimensions of Armored Concrete structures are not only of importance in saving dead space of buildings, but also in dimensions of foundation and retaining walls, where the saving is a great one. Where a foundation of five or six feet is required in ordinary masonry, it is possible to do this in Armored Concrete with a fifteen inch footing.

DECORATIVE QUALITIES OF ARMORED CONCRETE

Concrete, as a moulded material, can follow the design of any style of architecture, ranging from the old classic style to the Art Nouveau. The dimensions of all parts of the Hennebique System are adaptable and very small for the strength required. Concrete can also be colored, consequently a building can be finish, bush hammered or tooled. However, Concrete, considered as a durable and non-expensive material, shall be treated solely in reference to moulded monolithic structures and is thus particularly adapted to industrial buildings. Combined with artificial stone, bricks, terra cotta or marble, an Armored Concrete building can be decorated in the most elaborate manner.

In the following pages many examples are given of the interior or exterior parts of buildings, and the good results obtained by replacing masonry by Armored Concrete.

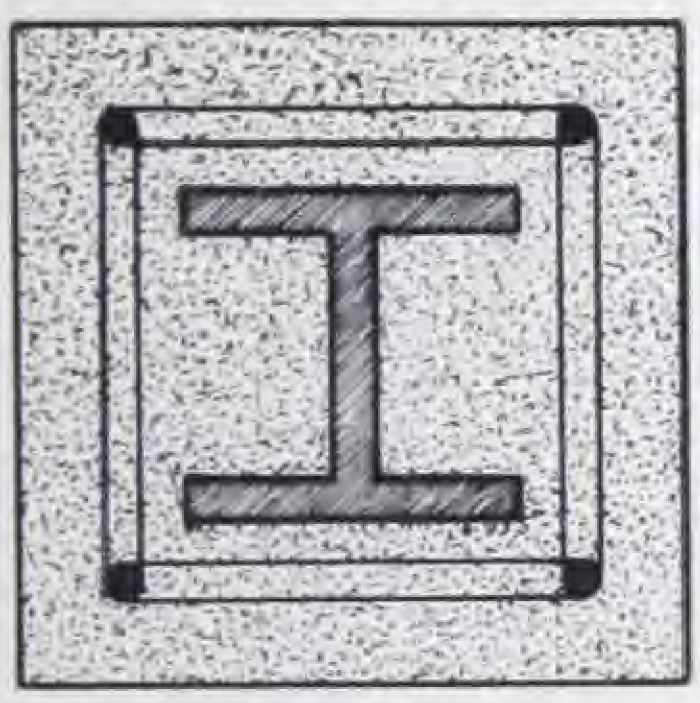


Fig. 14.

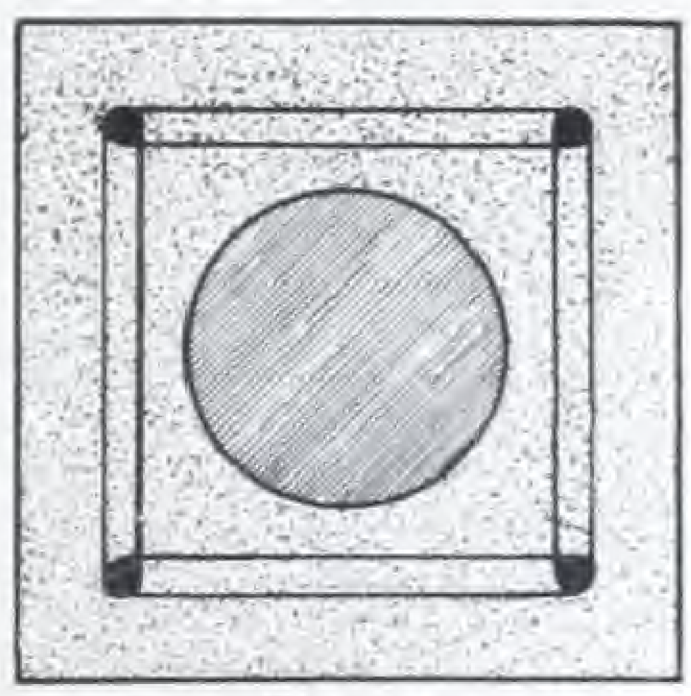


Fig. 15.

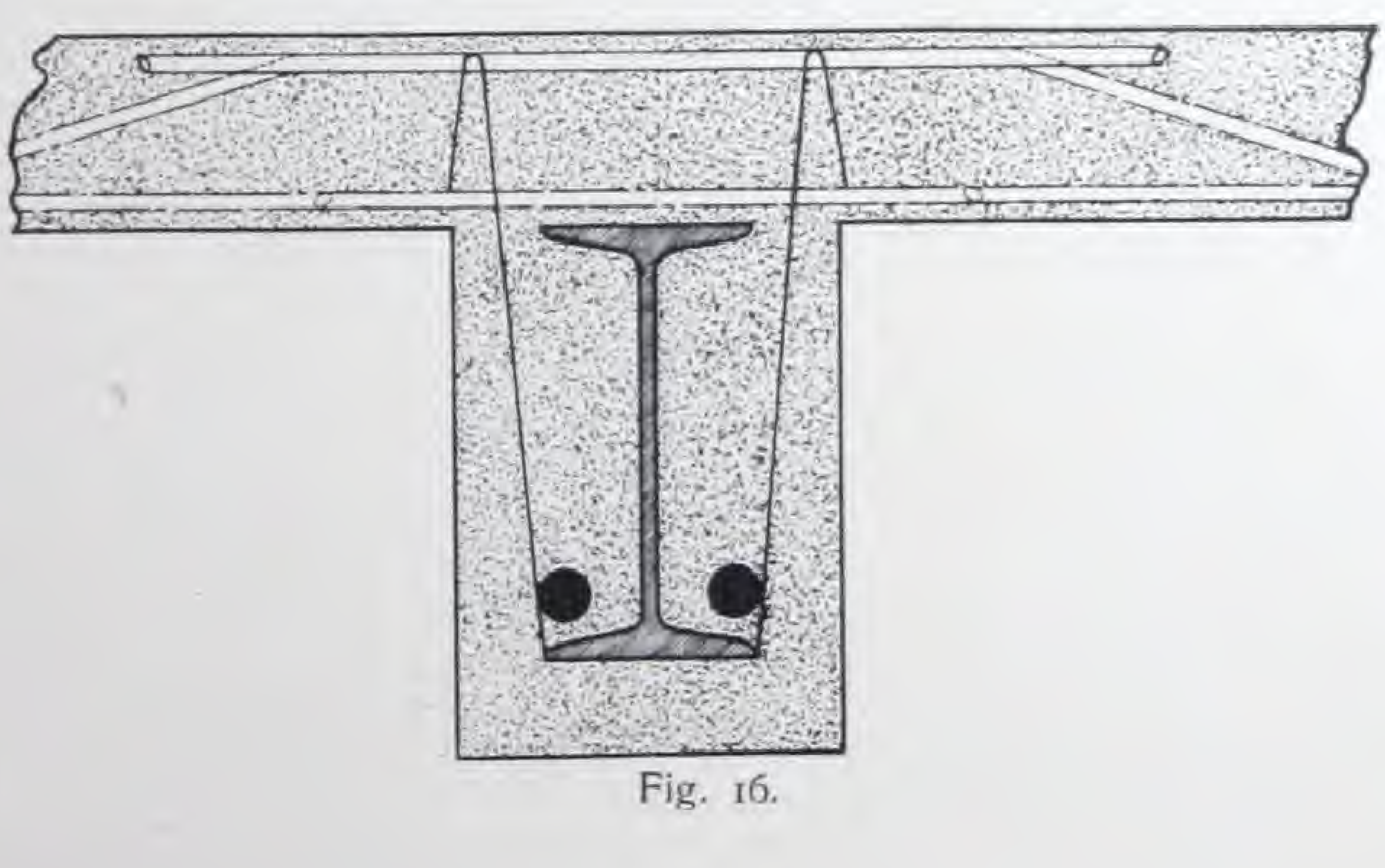


Fig. 16.

ADAPTABILITY

The adaptability of Armored Concrete was peculiarly shown in the case of the Hampton Hotel at Albany. This building was a steel skeleton structure with brick walls. The floors were constructed of brick arches between wooden joists. It was desired to construct Reinforced Concrete floors throughout, resting on steel beams and also to add three entire stories. It was necessary to strengthen the steel beams and cast iron columns already in place. Figs. 14, 15 and 16 show how simply and economically this was accomplished with Armored Concrete. The following letter from the Architect, Mr. Marcus T. Reynolds, shows that this work has proved entirely satisfactory:

ALBANY, March 15, 1907.

HENNEBIQUE CONSTRUCTION COMPANY.

GENTLEMEN: On completion of the Hampton Hotel in this city I would like to express to you my satisfaction with the results accomplished by your system of reinforced concrete. As you know, the old five story building, which made no pretence of being fireproof, was in a wretched condition, the walls being some of them over 90 years old and the iron floor beams and columns so overloaded that the wooden floors had settled to a dangerous point. If it were not for the elaborate granite facade, which had been put up in recent years, when the building was remodelled for a banking house and office building, we would have torn the entire structure down.

I do not believe that it would have been possible to have removed all the interior of the building and substituted fireproof construction as we did, or to have added the three additional stories by any other system than that of reinforced concrete, which enabled us to embody the remnants of the old building into the present monolithic structure. I think that the building is as substantial as a new building would have been.

Very truly yours,

MARCUS T. REYNOLDS.

TESTS.

ALL HENNEBIQUE STRUCTURES GUARANTEED

In taking contracts to erect Armored Concrete structures (Buildings, Bridges, Reservoirs, Penstocks, etc.) we always guarantee our construction and agree to test it. The tests made on our constructions are as numerous as the constructions themselves. It would be useless to print all of them in this catalog and only tests made several years ago will be given out. We refer to tests made in Laboratories; these can be found in the technical bulletins and journals, but we caution, however, the reader against accepting tests made by concerns who advertise bars. We would suggest reading the reports of the tests made at the Watertown Arsenal and published by the United States War Department, and also the report of the Rapid Transit Commission on tests at the Columbia University. We refer also to tests conducted at the World's Fair by Mr. R. Humphrey, who is Secretary of the Association of American Portland Cement Manufacturers, and whose high standing as a concrete expert is a guarantee of the value of these tests. The analysis of these tests was published by the Engineering News of September 21, 1905. We are indebted to them for the cuts here published:

RELIABLE TESTS

> "Four beams were made, three of these (two of rectangular and one of T-section) were made according to the Hennebique System; and the other, also rectangular in section, according to the Kahn System. *The beams of the rectangular section were made under identical conditions and were designed to carry the same load using the same percentage of steel reinforcement.* These beams were made in the open air and were not wetted after being made and the forms were removed just before the tests were made at the end of 60 days. The beams remained in the open air during that time and were not moved until tested."

Fig. 17.

Fig. 17 shows the condition of the beams after testing; the photographs are not, however, sufficiently clear to show the location of the hair cracks.

The following is the result of the tests of these beams in the order in which they were tested:

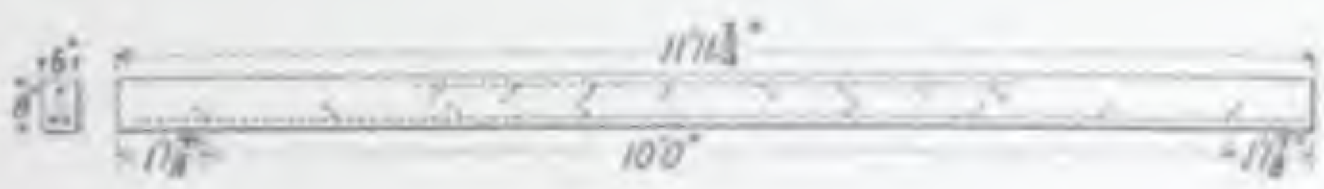


Fig. 18.

Beam 1.—Kahn System—Length over all, 11' 11¾"; clear span, 10'; breadth, 6⅛"; depth over all, 8½"; depth to centre of steel, 7¼"; compressive strength concrete, 1,747 lbs. per sq. in.; weight of beam, 593 lbs.; mixture, 1:2:4; reinforcement in top, one ½" Kahn bar, 9' long; reinforcement in bottom, two ½" Kahn bars, 11' 11¾" long.

Steel in tension 1.59%
Steel in compression .... .80%

Total steel 2.39%

Loads, Lbs.	Deflection, In.	Remarks.
1350	3/32	
2350	1/8	
3350	5/16	Crack appeared on right under end of top of reinforcing bar.
4350	3/8	Crack appeared on left under end of top of reinforcing bar.
6350	17/32	
7350	5/8	
7770	7/84	Failed by concrete crushing around ends of top of reinforcing bar. Concrete buckled at the ends of top bar.

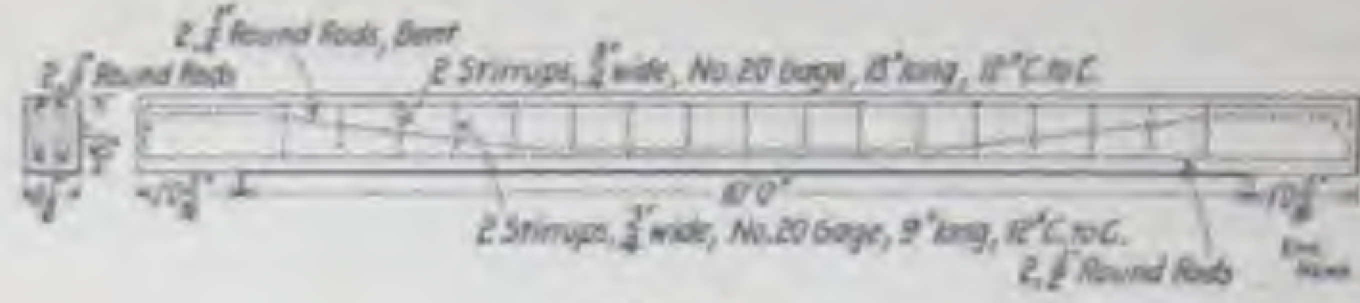


Fig. 19.

Beam 2.—Hennebique System—Length over all, 12' 5⅝"; clear span, 10' 6⅛"; depth over all, 8½"; depth to centre of steel, 7½"; weight of beam, 620 lbs.; mixture, 1:2:4; compressive strength of beam, 60 days, 1,747 lbs. per sq. in.

Steel in tension.. 1.60%
Steel in compression...................................... .80%

Total steel.. 2.40%

Loads, Lbs.	Deflection, In.	Remarks.
1850	3/32	
2350	1/8	
4350	5/16	
5350	7/16	
6350	9/16	Hair cracks appeared on either side of centre, very faint.
7650	13/16	
8150	15/16	Cracks became more general.
8450	1 13/16	Failed by concrete buckling in centre of beam.

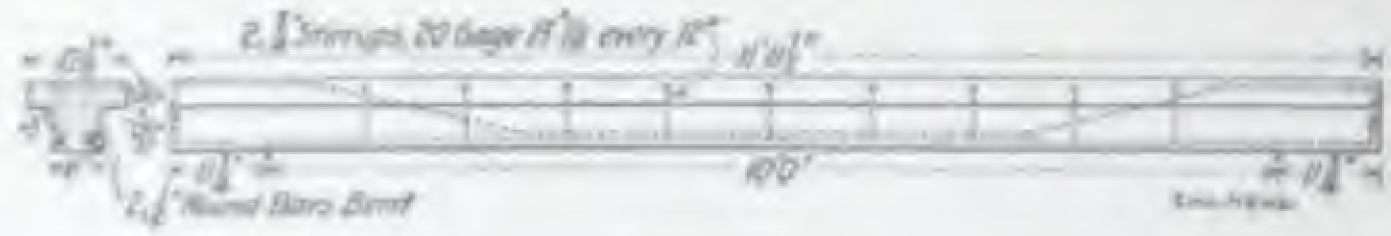


Fig. 20.

Beam 3.—Hennebique System—Length over all, 11' 11½"; clear span, 10'; breadth, 12-18"; depth over all, 9"; depth to centre of steel, 7½"; weight of beam, 876 lbs.; mixture, 1:2:4; strength of beam, 60 days, 1,747 lbs. per sq. in.

Loads, Lbs.	Deflection, In.	Remarks.
2350	1/8	
4350	5/32	
6350	3/8	
7950	15/32	First hair cracks appeared in centre.
8350	9/16	
8750	7/8	Failed by concrete crushing at top in centre of beam.

Fig. 21.

Beam 4.—Hennebique System—Length over all, 12' 3½"; clear span, 10'; breadth, 6⅛"; depth over all, 8½"; depth to centre of steel, 7½"; weight of beam, 614 lbs.; mixture, 1:2:4; compressive strength, 60 days, 1,747 lbs. per sq. in.

Steel in tension.. 1.60%
Steel in compression...................................... .80%

Total steel.. 2.40%

Loads, Lbs.	Deflection, In.	Remarks.
1350	1/16	
2350	1/8	
3350	3/16	
4350	7/32	
5350	3/8	
6350	1/2	Faint hair cracks on either side, centre very faint.
7350	19/32	
8350	13/16	
8650	1	Failure by concrete buckling, top in centre.

It is to be concluded that in these tests, Hennebique Beams, constructed with mild steel, bought in the open market, showed a strength from 10% to 15% greater than the patented bar system beam constructed under identical conditions and using the same amount of materials—concrete and steel.

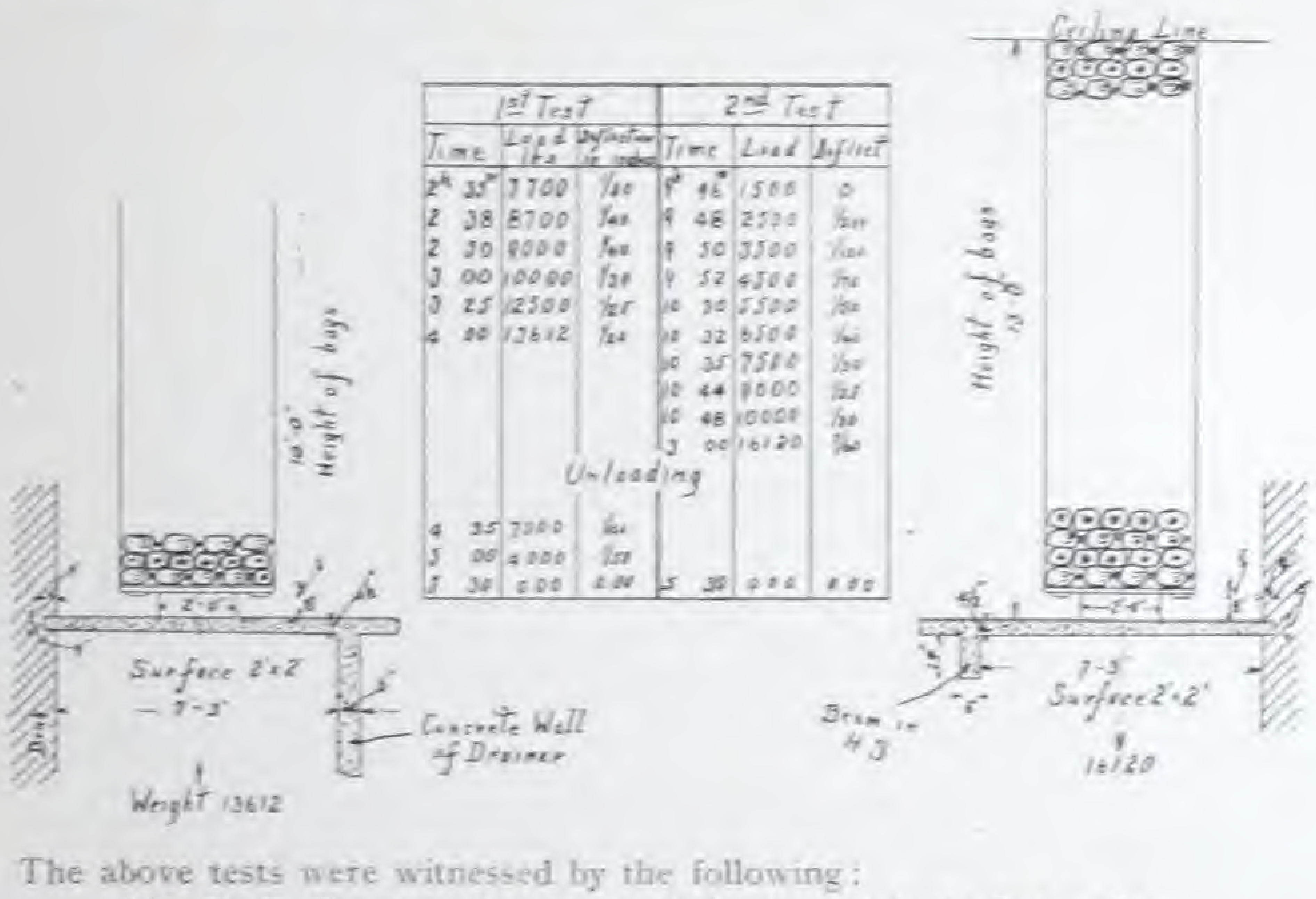
REPORT ON TESTS MADE ON THE DRAINER ROOM FLOOR CONSTRUCTED IN THE HENNEBIQUE SYSTEM AT THE PLANT OF THE BY-PRODUCTS PAPER COMPANY, NIAGARA FALLS, N. Y.

Mr. G. F. Hardy, Architect.
Mr. B. F. French, President.
Mr. G. F. Lull, Superintendent.

TESTS MADE ON JULY 9-10, 1903.

Floors designed for 300 lbs. per square foot. Clear span 7' 3", thickness 4½". Test weight concentrated on a surface of 2' x 2'. Two different points chosen by the Architect were tested.

Deflections were as follows:



1st Test			2nd Test		
Time	Load lbs.	Deflection in inches	Time	Load	Deflect.
2h 35m	7700	[illegible]	9h 46m	1500	0
2 38	8700	[illegible]	9 48	2500	[illegible]
2 50	9000	[illegible]	9 50	3500	[illegible]
3 00	10000	[illegible]	9 52	4500	[illegible]
3 25	12500	[illegible]	10 30	5500	[illegible]
4 00	13612	[illegible]	10 32	6500	[illegible]
			10 35	7500	[illegible]
			10 44	8000	[illegible]
			10 48	10000	[illegible]
			3 00	16120	[illegible]
Unloading					
4 35	7000	[illegible]			
5 00	4000	[illegible]			
5 30	000	0.00	5 30	000	0.00

The above tests were witnessed by the following:

Mr. B. F. French, *President of the By-Products Paper Co.*
Mr. George T. Roberts, *Civil Engineer.*
Mr. George F. Lull, *Superintendent of the By-Products Paper Co.*
Mr. Thomas H. Ryan, *Representative of the Architects.*
Mr. N. B. Giouros, *Engineer of the Hennebique Company*

New York, June 22, 1904.

Mr. R. Baffrey, *Manager*,
Hennebique Construction Co.,
1170 Broadway, New York City.

Dear Sir: Replying to your favor of the 22d inst. regarding the reinforced concrete floors and tanks which you have built for me at Niagara Falls, N. Y., I am pleased to say that they were very satisfactory.

You may use my name as reference for the quality of your work.

Yours very truly,

George F. Hardy.

TYPICAL CONSTRUCTIONS

The following are photographs of constructions in the Hennebique System erected both abroad and in this country.

They show how easily the principles previously set forth can be adapted to the different problems in the Construction World.

From the thirty thousand works already executed in the Hennebique System we show only a very few that can be called typical. It is seen that walls, floors, panelled ceilings, factories, warehouses, coal pockets, grain elevators, foundations, grillages, piles, tanks, reservoirs, sewers, pipes, retaining walls, piers, quay walls, etc., have been constructed in Armored Concrete, and in all cases it has successfully improved upon the old methods of construction.

WM. McKINLEY HIGH SCHOOL, ST. LOUIS, MO.

WM. B. ITTNER,
Commissioner of School Buildings.

[illegible] LLOYD,
General Contractor.

WM. McKINLEY HIGH SCHOOL, ST. LOUIS, MO.

GENERAL VIEW OF BUILDING

In this handsome structure Armored Concrete has been used in all the structural parts, such as floors, roofs, stairs, columns and footings. There are arched floor slabs of 18' span, flat floor slabs of 16' span, concrete girders of 30' and 32' span, and columns of a diameter of 1-16 of their height.

Tests were made to ascertain the strength of the floors on both beams and floor slabs, with the results as given in the following testimonials:

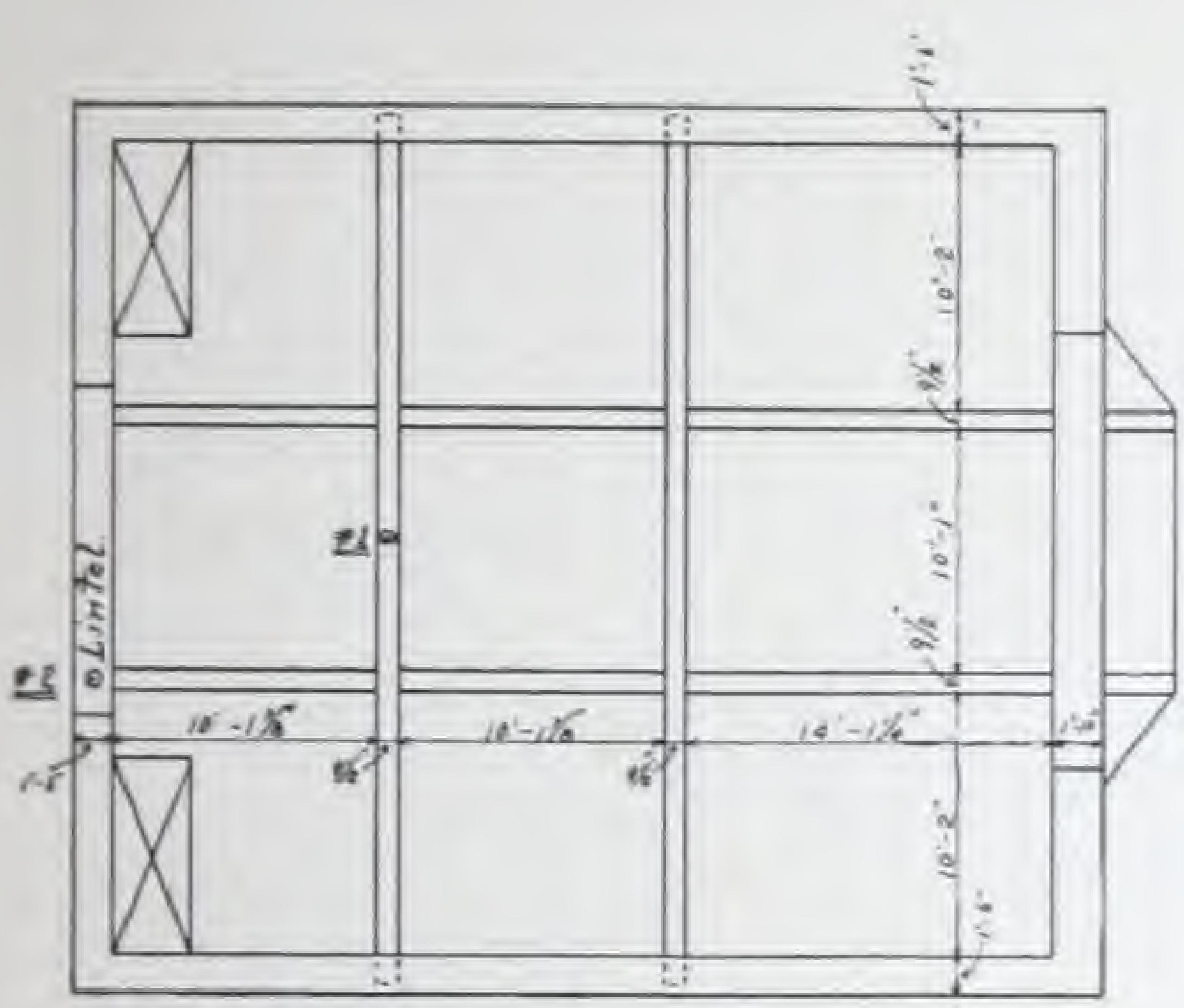
WASHINGTON UNIVERSITY, TESTING LABORATORY.

J. L. VAN ORNUM, M. A. M., SOC. C. E., PROF. OF C. E., DIRECTOR.

ST. LOUIS, MO., JUNE 23, 1903.

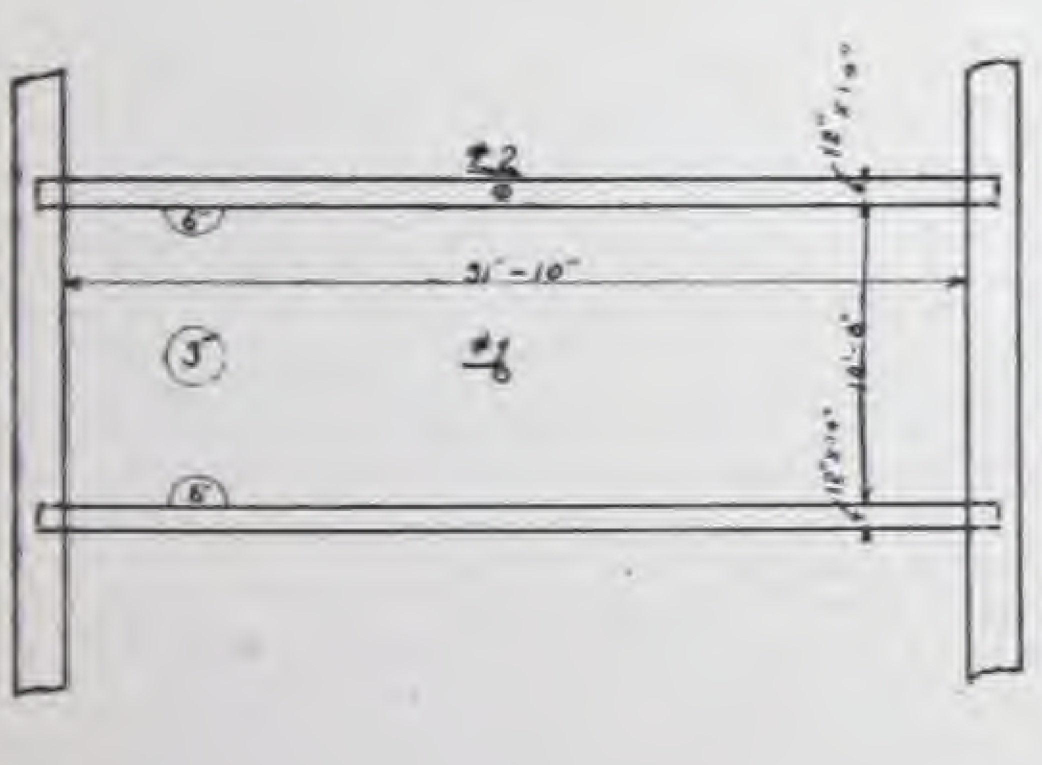
REPORT OF TESTS ON FLOORS OF McKINLEY HIGH SCHOOL

GENTLEMEN: Two weeks ago a test was made of the floor beams (constructed under the Hennebique Patents) of the "library room" of the new McKinley High School of this city by loading the whole floor and observing the deflection. The dimensions and arrangement of the floor system are shown in the following sketch:



Two deflectometers were placed as indicated by cross marks, No. 1 giving the total deflection under the beams and No. 2 giving the corresponding deflections at the lintel supporting the ends of the cross-beams on the south side. The loads and corresponding deflections were as follows:

Load.	No. 1.	No. 2.
About 105 lbs. per sq. ft.	0.087 inch	0.000 inch
About 160 lbs. per sq. ft.	0.165 inch	0.000 inch
About 220 lbs. per sq. ft.	0.323 inch	0.008 inch



Under the maximum load given the deflection of the beam was then 1-1190 of the span; after the removal of this load the beam did not return to its original position, there remaining a permanent deflection of 0.118 inch, or 1-3250 of the span.

Yesterday a similar test was made of the floor (also of Armored Concrete construction) in the "biological room" of the same building to determine the behavior under load of the floor arch, or slab, itself. In this case the cross-hatch area in the following sketch was uniformly loaded and the deflectometers were placed as indicated.

The results of this test were as follows:

DEFLECTOMETER READING.

Load.	No. 1.	No. 2.	Deflection.
90 lbs. per sq. ft.	0.055 inch.	0.000 inch.	0.056 inch.
188 lbs. per sq. ft.	0.130 inch.	0.024 inch.	0.106 inch.
235 lbs. per sq. ft.	0.173 inch.	0.043 inch.	0.130 inch.
283 lbs. per sq. ft.	0.221 inch.	0.067 inch.	0.154 inch.
330 lbs. per sq. ft.	0.275 inch.	0.094 inch.	0.181 inch.
400 lbs. per sq. ft.	0.378 inch.	0.142 inch.	0.236 inch.

The column headed "deflection" gives, of course, the actual independent maximum deflection of the floor-slab itself, of 10 ft. 8 in. clear span. The loading took about two hours, and the maximum deflection of the floor-slab is seen to be 1-540 of the span.

Three hours after the maximum load had been reached, when the load was entirely removed, the permanent deflection remaining in the floor arch was 0.055 inch, or 1-2330 of the span, while deflectometer No. 2 read zero, showing the complete recovery of the adjoining floor-beam.

Respectfully submitted,

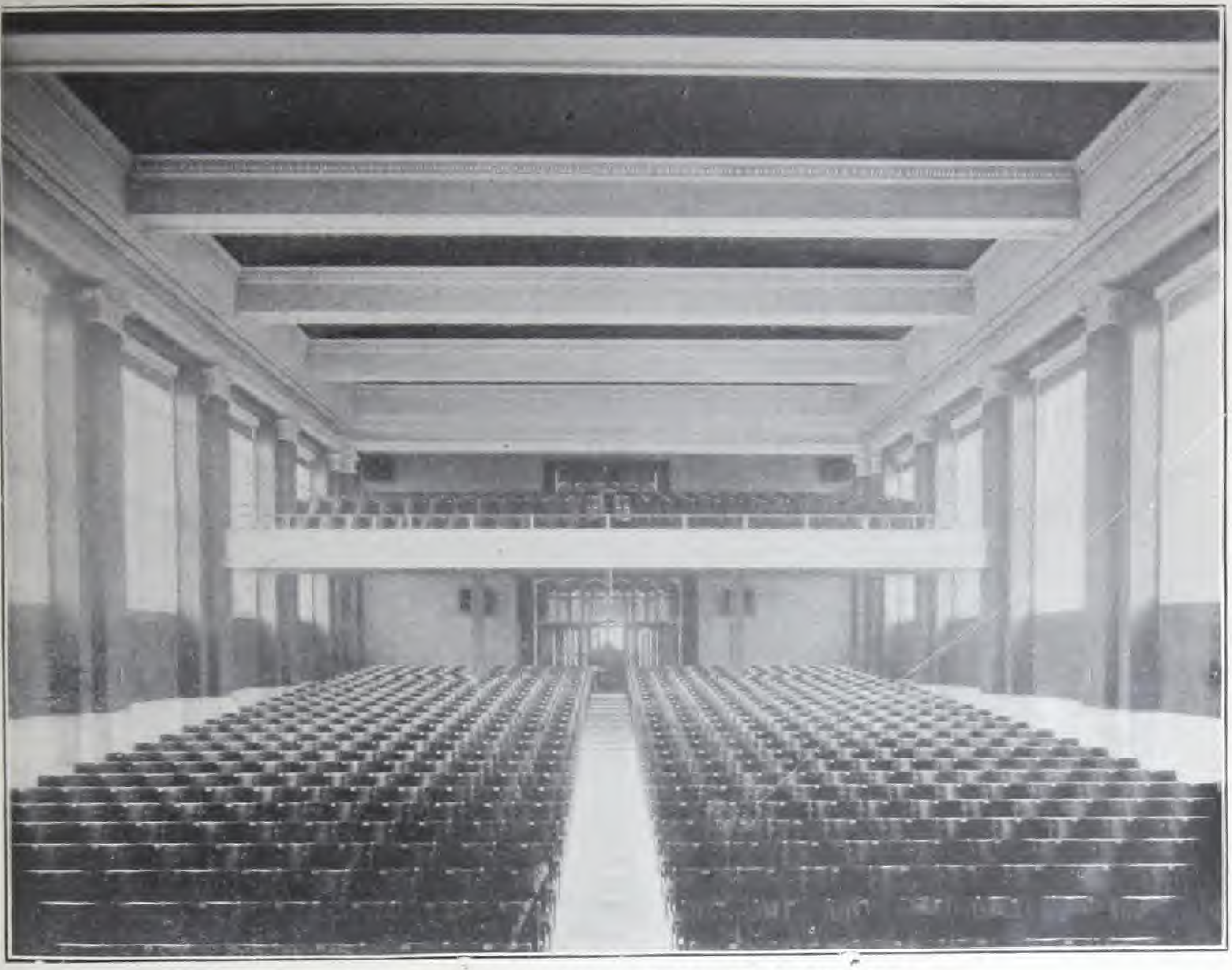
(Signed) J. K. Van Ornum.

The above tests were witnessed by the following:

(Signed) Wm. B. Ittner, Commissioner School Buildings.
Jean Jameton, Contractor.
Hiram Lloyd, General Contractor.
H. Brussel, C. E., Engineer of the Hennebique System.

WM. McKINLEY HIGH SCHOOL, ST. LOUIS, MO.

Test over entire floor of Library Room. 112 tons gives a deflection of 0.323 inches.



WM. McKINLEY HIGH SCHOOL, ST. LOUIS, MO.

Auditorium Ceiling. Girder of 50 feet span on which plaster finish is directly applied, avoiding the use of metal lath furring.

BOARD OF EDUCATION OF THE CITY OF ST. LOUIS.

OFFICE OF THE COMMISSIONER OF SCHOOL BUILDINGS.

St. Louis, March 22nd, 1904.

Hennebique Construction Co.,

No. 1170 Broadway, New York City.

TESTIMONIAL OF COMMISSIONER OF SCHOOL BUILDINGS

Gentlemen: Replying to your letter of inquiry regarding the work executed in the Wm. McKinley High School by your St. Louis representatives, will say that the same has been executed in a thoroughly satisfactory manner.

The test made of the construction by Prof. J. L. Van Ornum, of the Washington University, a copy of which I mailed you, shows that the construction meets fully all the requirements of the specifications.

In my opinion, your method of construction is not only based upon scientific principles, but adds materially to the rigidity of the building by reason of the fact that the floor slabs are built into and form a part of the masonry walls.

Yours respectfully,

(Signed) Wm. B. Ittner,

Commissioner of School Buildings.

SALVATION ARMY CITADEL, CLEVELAND, O.

Balcony and Railing in Armored Concrete. FREDERIC BAIRD, Architect

This building is a six story one, with all the structural parts in Armored Concrete, viz.: Foundations, columns, floors, roofs, balcony of auditorium and stairs.

An interesting point in the construction, and one showing how readily Armored Concrete may be adapted to all circumstances, is that the beams resting on the walls were concreted in two different parts at an interval of two weeks.

During the course of construction, the bricklayers were on a strike, and in order to delay the work as little as possible, the floors were concreted within two feet of the walls on which they were to rest; two floors were thus concreted in advance of the bearing walls.

When the bricklayers returned to work, the floors were completed. The beams which were concreted in two parts are equally as strong as the others, and do not show any cracks.

Tests were made with the following results:

CERTIFICATE OF TESTS OF CONCRETE STEEL FLOORS, HENNEBIQUE SYSTEM, AT SALVATION ARMY CITADEL.

MR. B. P. FARAGHER, Rose Building, City.

TESTIMONY OF ARCHITECT

DEAR SIR: I with pleasure certify that the concrete floors in the Salvation Army Citadel, Cleveland, lately constructed by you, in the Hennebique System, were tested on the 16th inst. in the following manner in my presence, and I consider the trial and results very satisfactory:

The floor was guaranteed to carry safely a superimposed load of one hundred and fifty pounds (150 lbs.) per square foot with a maximum deflection of 1/800 of the span, or 11/32" for one and one-half times the specified load of 225 pounds per square foot.

The floor panel tested has an area of one hundred and sixty-five (165) square feet, being 7' wide and 23' 7" long, having the length of the clear span of the supporting beam.

The floor plate was 4" thick and the beam has a section of 8" x 16" exclusive of the floor. The load applied was sand and gravel weighing one hundred and ten pounds (110 lbs.) per cubic foot, placed in a wooden bin covering the area to be loaded.

Two deflectometers were used in determining the deflection of the beam, which was supported at one end by a column and at the other end by a lateral beam of the same section.

Instrument No. 1 was placed at the centre of the beam, and Instrument No. 2 at the end supported by the lateral beam.

The net deflections in centre of beam from its original position under different loads per square foot of loaded area were as follows:

For 2	feet	sand	and	gravel	220	lbs.	per	sq. ft.,	3/32"
" 3	"	"	"	"	330	"	"	"	5/32"
" 4	"	"	"	"	440	"	"	"	7/32"
" 4½	"	"	"	"	525	"	"	"	5/16"

On the following day the load was further increased to six hundred pounds (600 lbs.) per squart foot, when the deflection was found to be 13/32".

Another floor panel 10 feet by 12 feet clear span between the supporting beams was tested at the same time. This floor was also figured to carry safely a superimposed load of one hundred and fifty pounds per square foot.

Under a distributed load of four hundred and fifty pounds (450 lbs.) per square foot the deflection at centre of panel was a little less than 3/32".

The tests developed no failure of any sort in either case.

Respectfully yours,

(Signed) FREDERICK BAIRD, Architect.

NEW YORK, May 28, 1904.

THE HENNEBIQUE CONSTRUCTION COMPANY,

No. 1123 Broadway, New York City.

FOUNDRY FLOOR FOR THE J. L MOTT IRON WORKS

GENTLEMEN: As per your verbal request, I have much pleasure in stating to you that the armored concrete floor which you constructed in our foundry, at our new plant, at Trenton, N. J., 380 feet by 80 feet, has proved so far perfectly satisfactory and stood the test of 450 lbs. with slight deflection and resumed its original position as soon as the load was removed.

The construction gives us a very capacious and useful cellar for the storing of patterns, etc., etc.

Yours truly,

THE J. L. MOTT IRON WORKS,

A. G. THOMSON, Architect.

TESTING OF A 61 FOOT SPAN GIRDER.

GUSTAVE H. DRACH, Architect.

CINCINNATI, O., Aug. 27, 1903.

HENNEBIQUE CONSTRUCTION COMPANY,

No. 1170 Broadway, New York City.

TESTIMONIAL OF GUSTAVE H. DRACH

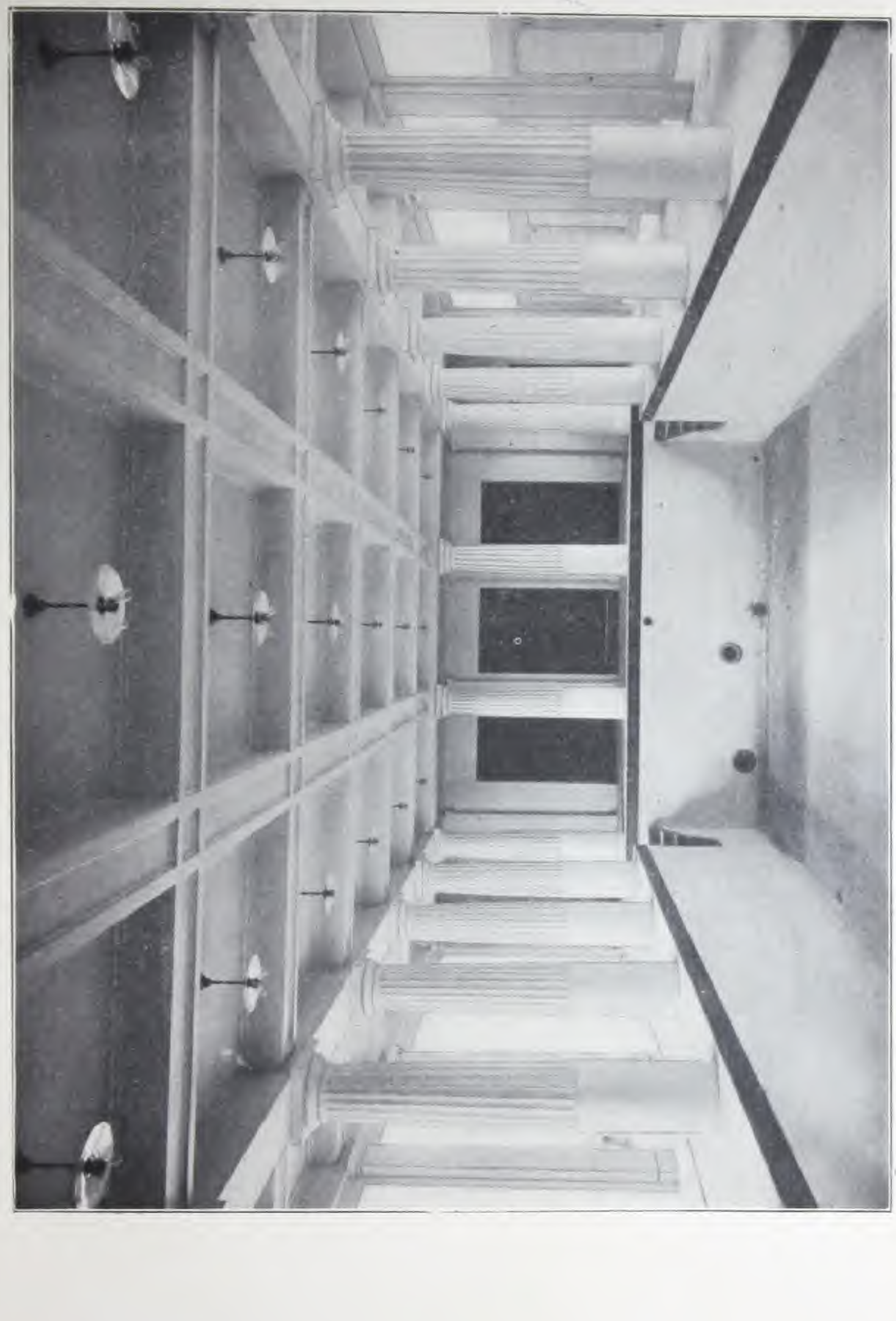
DEAR SIRS: The test of the balcony at the College of Music was very satisfactory. The balcony, with girders of 61 foot span, was loaded in the center a little over 51,000 lbs., the deflection was 3-16 inch. We propose to allow the load to remain until to-morrow. The deflection has not increased any from 4 p. m. yesterday up to 9 this morning.

Yours very sincerely,

GUSTAVE H. DRACH.

SALVATION ARMY CITADEL, CLEVELAND, O.
Third floor. To be used as Dormitory.

CONCRETE STAIRS IN THIELMANN WAREHOUSE, BALTIMORE, MD.



BALTIMORE ATHLETIC CLUB BUILDING.

Messrs. PARKER & THOMAS, Architects.

Swimming Pool. 70 x 22 ft. Walls 4 in. thick, lined with enameled tile.
Paneled ceiling obtained by arrangement of projecting beams.

ST. THOMAS AQUINAS SCHOOL.

New York City. JOHN KERBY, Architect

WASHINGTON, April 10, 1902.

SNOWDEN ASHFORD, ESQ., Inspector of Buildings,

IN RE "HENNEBIQUE SYSTEM."

MOVING LOAD TESTS ON HENNEBIQUE FLOORS AT WASHINGTON, D. C.

SIR: In compliance with your orders of the 9th inst., we were present at the application of test loads on thirty days' old "Hennebique System," of Armored Concrete construction, first floor and sustaining columns, St. Martin's Parish Hall, now in course of erection, N. Capitol and F Streets, N. W., by Mr. Owere Donnelly, Builder.

The requirements of this department were that the floor be loaded up to 350 lbs. per sq. ft.

The contractor had a broad wheel flat handcar loaded up with 1,590 lbs. of iron—397 lbs. per sq. ft.—this weight being imposed on the centre of a panel without appreciable deflection; the car was then run rapidly over the several panels. The greatest panel deflection being 1-16th inch. The greatest 16 ft. 0 inch, span concrete girder deflection being 1-32.

The load on car was then increased to 2,223 lbs., 555¾ lbs. of load per sq. ft., this being imposed on the centre of a panel without appreciable deflection. The car again being run rapidly over the several panels, the deflections being slightly in excess of those above noted.

We desire to call attention to the very slight vibration during the rapid motion tests. We placed our shoulders hard up against the under side of 3½ panels of concrete while the 1,590 lbs. load and the 2,223 lbs. load were being pulled rapidly over us, and detected but little tremor, and that in our judgment travelling in a horizontal direction, with the car's motion.

We consider this test in every way satisfactory.

Very respectfully,

(Signed) JOHN STEALY, Ass't Inspector of Bldg.

(Signed) C. W. SOMERVILLE, Computer, Bldg. Department.

WATER TOWER AT FORT REVERE, MASS., U. S. A.

The Water Tower encloses a standpipe 50 feet high. Diameter 20 feet.
Thickness of tank at the top 3 inches increasing to 7 inches at the bottom.
The skeleton of the tower is also in Armored Concrete, Hennebique System, with exterior cement finish, and brick curtain wall. This work was done for the U. S. War Department.

HENNEBIQUE SYSTEM AT U. S. NAVAL ACADEMY, ANNAPOLIS, MD.

MARINE AND ENGINEERING BUILDING

Annapolis, Md. ERNEST FLAGG, Architect

HENNEBIQUE SYSTEM IN BUILDINGS AT U. S. NAVAL ACADEMY

The Hennebique System is extensively used by the United States Government in the construction of the numerous buildings erected at the Naval Academy, Annapolis, Md. It replaces, in these structures, all the structural steel for columns, beams, girders, floors, stairs, etc.

The architect for the above buildings was Mr. Ernest Flagg, No. 35 Wall St., New York City, and he gives his opinion of the Hennebique System as follows:

ERNEST FLAGG, ARCHITECT,
No. 35 WALL ST.

New York City, Feb. 5, 1904.

The Hennebique Construction Co.,
No. 1170 Broadway, New York City.

TESTIMONIAL OF MR. ERNEST FLAGG

Gentlemen: In reply to your letter of Feb. 2nd, I take pleasure in saying that we have used your system of construction in a number of important buildings, and think highly of it.

Yours truly,

Ernest Flagg.

Boston, Mass., July 28, 1904.

Hennebique Construction Co.,
No. 1170 Broadway, New York, N. Y.

HENNEBIQUE SYSTEM IN STANDPIPES FOR WAR DEP'T

Gentlemen: The water tower at Fort Revere has proven very satisfactory and is considered by all an excellent piece of work.

Irs. S. Frederdall,
Captain and Quartermaster, U. S. A. Dept. Quartermaster.

STORE AND OFFICE BUILDING.

Philadelphia, Penn. Messrs. PRICE & MCLANAHAN, Architects

Six story skeleton construction.

LEONORIA STORAGE WAREHOUSE.

BARNETT, HAYES & BARNETT, Architects.

R. U. LEONORIA, JR., & COMPANY, Owners.

This is a typical storage warehouse. It has six stories, and covers a plot 100'x120'. The column spacing is 13' 0"x16' 4". The slabs are of the arched type, 13' 0" span, the rise being 4".

Extensive tests were made under the direction of Mr. Heimburger, the Building Commissioner of the city of St. Louis, and Mr. Van Ornum, Prof. of Civil Engineering of Washington University. The columns were tested up to 1,400 lbs. per sq. inch, and were subjected to eccentric loading. The beams and floor slabs were loaded with three times the live load for which they were designed. All of these tests gave the most satisfactory results.

R. U. LEONORIA & CO.'S WAREHOUSE, ST. LOUIS, MO.

Typical floor. Floor slabs, 13 ft. span. Super-imposed load, 200 lbs. per square foot.

OFFICE OF THE COMMISSIONER OF PUBLIC BUILDINGS.

CITY OF ST. LOUIS, Feb. 15th, 1904.

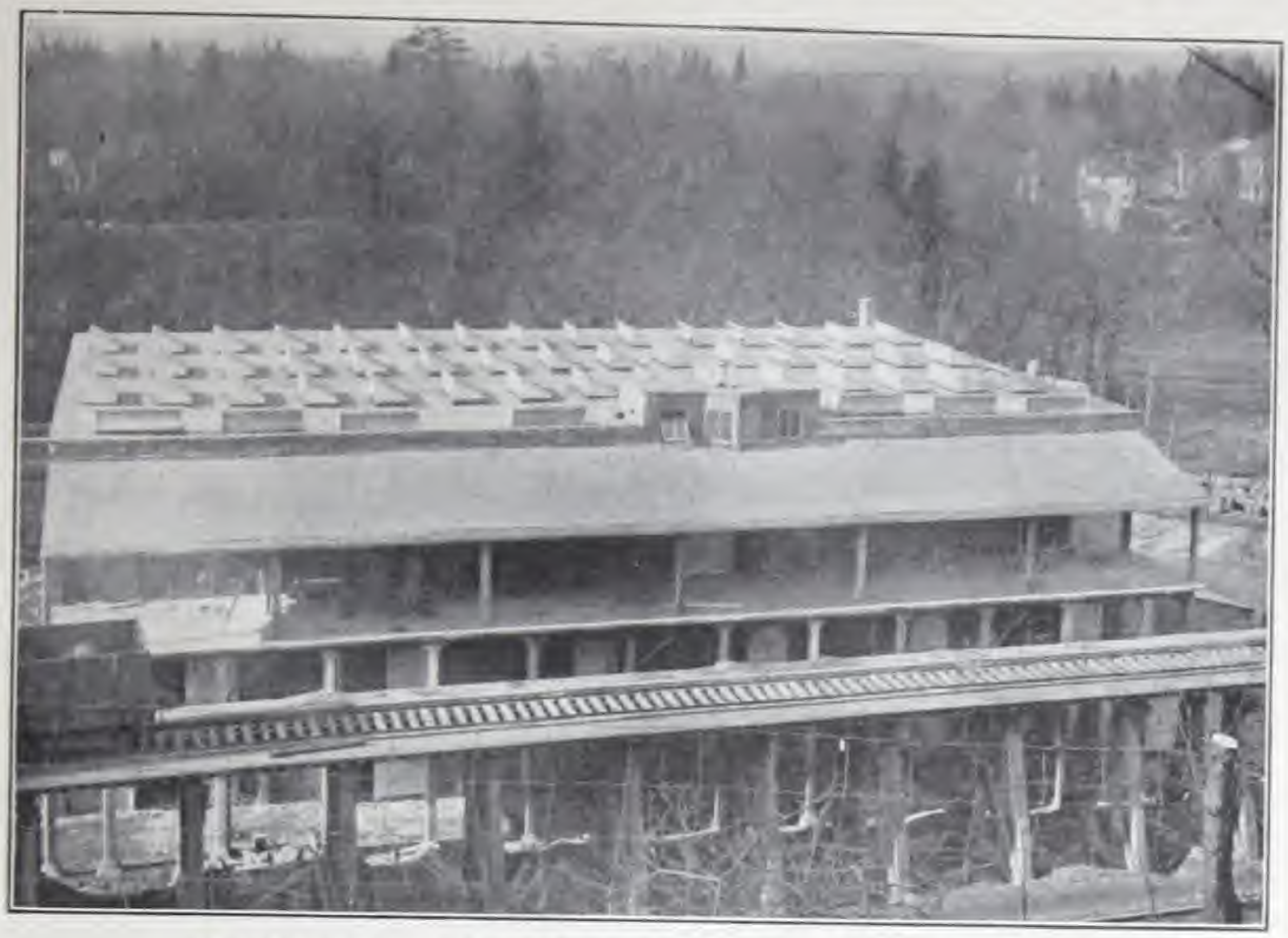
TESTIMONIAL OF BUILDING COMMISSIONER

TO WHOM IT MAY CONCERN:

I was a witness to the test applied to the Hennebique System of concrete floors, girders, columns, etc., at the Leonoria Storage Warehouse, at Grand and Laclede Aves., this city, and while I cannot positively testify as to the amount of weight to the sq. ft. that was placed in these tests, I can say that to the best of my knowledge the weight per sq. ft. that they claim was applied is correct, and I have the utmost confidence in this system of construction of girders, floors, etc., and would not hesitate to recommend it for floors carrying any weight that might be desired.

Respectfully,

G. U. HEIMBURGER,
Commissioner of Public Buildings.



STOREHOUSE, STANDARD TABLE OIL CLOTH COMPANY.

Buchanan, N. Y. Messrs. EDWIN QUICK & SONS, Architects

Entire construction in Armored Concrete; walls 4 in. thick.

GREENPOINT CARNEGIE LIBRARY.

Interior view.

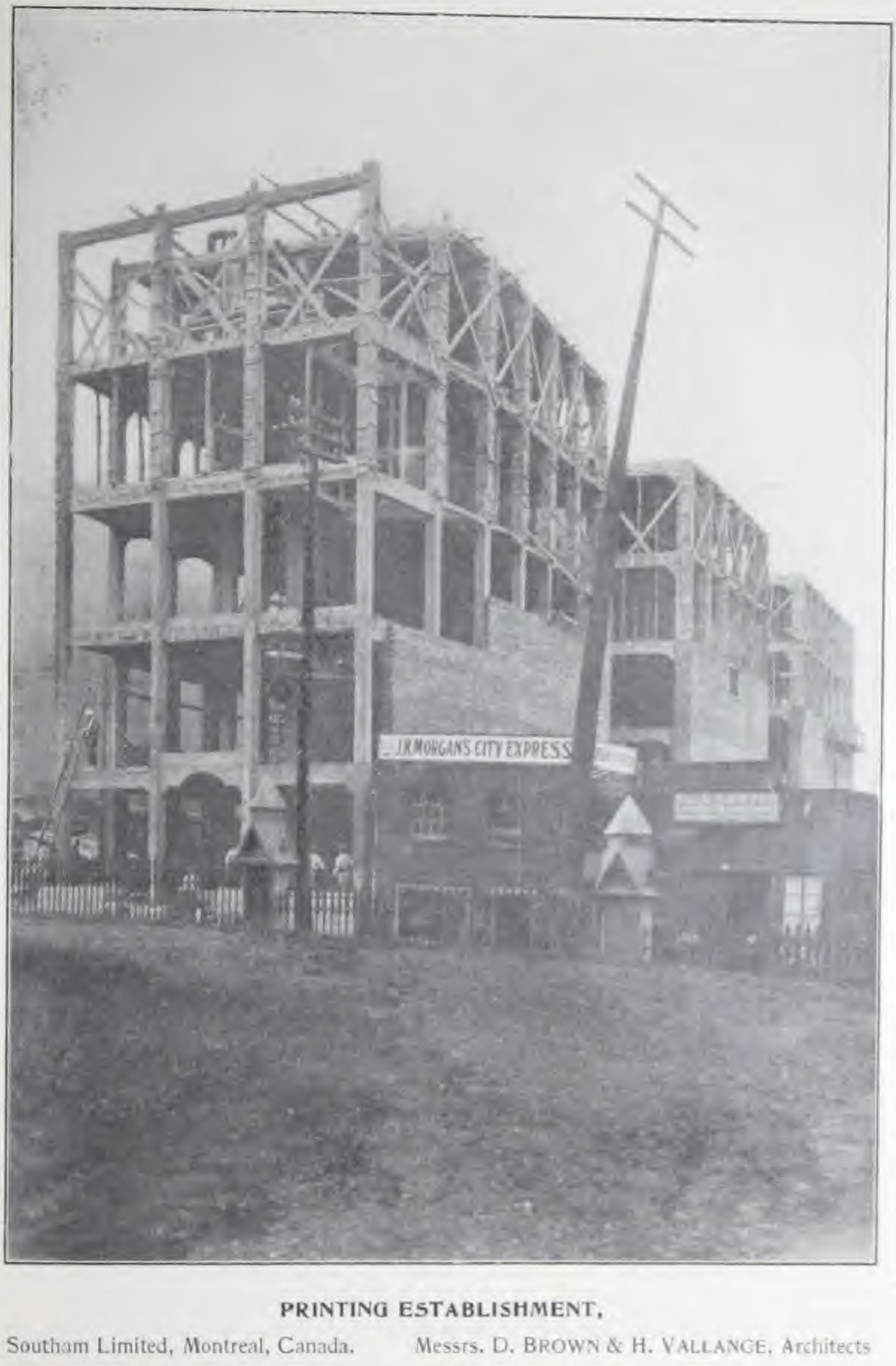
GREENPOINT CARNEGIE LIBRARY,

Brooklyn, N. Y. Mr. R. L. DAUS, Architect

All floors and roof in Armored Concrete.

FLATBUSH CARNEGIE LIBRARY,

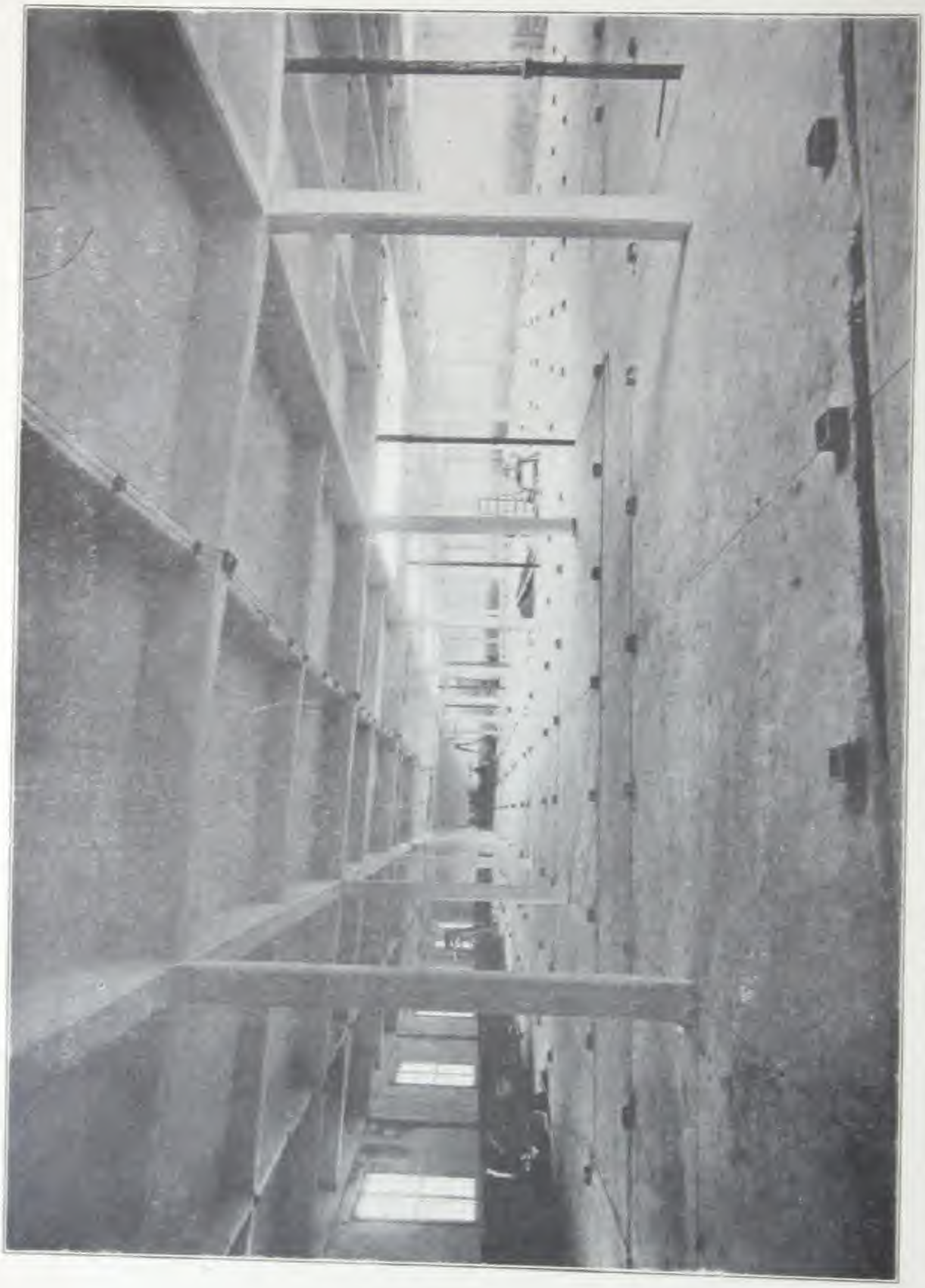
Brooklyn, N. Y. Messrs. LORD & HEWLET, Architects



PRINTING ESTABLISHMENT,

Southam Limited, Montreal, Canada. Messrs. D. BROWN & H. VALLANCE, Architects

This 6-story structure, 250 ft. by 35 ft., Armored Concrete skeleton, is a sample of quick construction, each tier having been constructed in 8 days.



STABLE FOR THE UNITED STATES EXPRESS COMPANY,

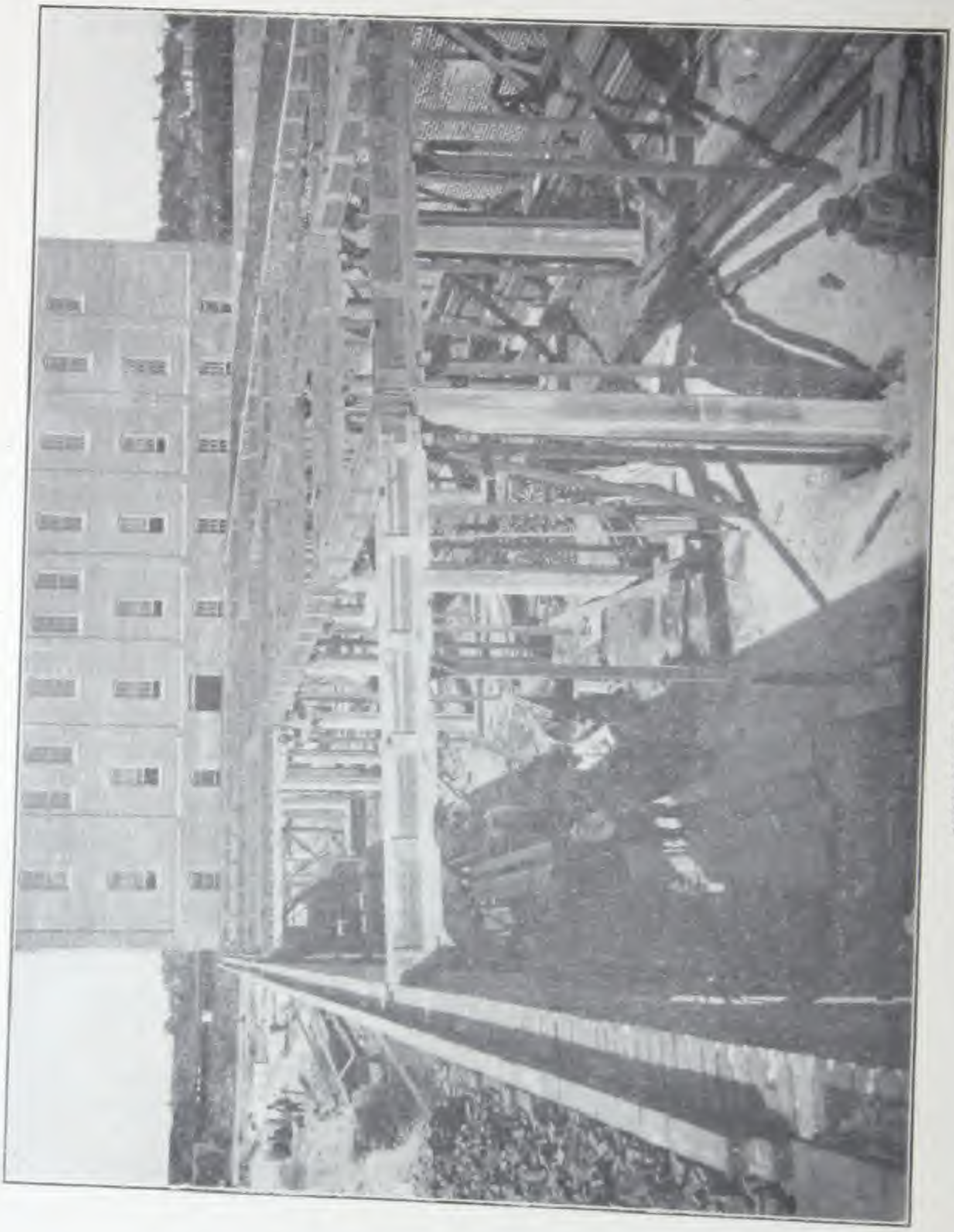
Jersey City, N. J. Mr. ERNEST FLAGG, Architect

This one story building of 50,000 sq. ft. was built in fifty days.

BURDETT BUILDING, TROY, N. Y.

CLEMENT B. BRUN, Architect

Structural parts in Armored Concrete. Front in artificial stone, imitation of Indiana Limestone.

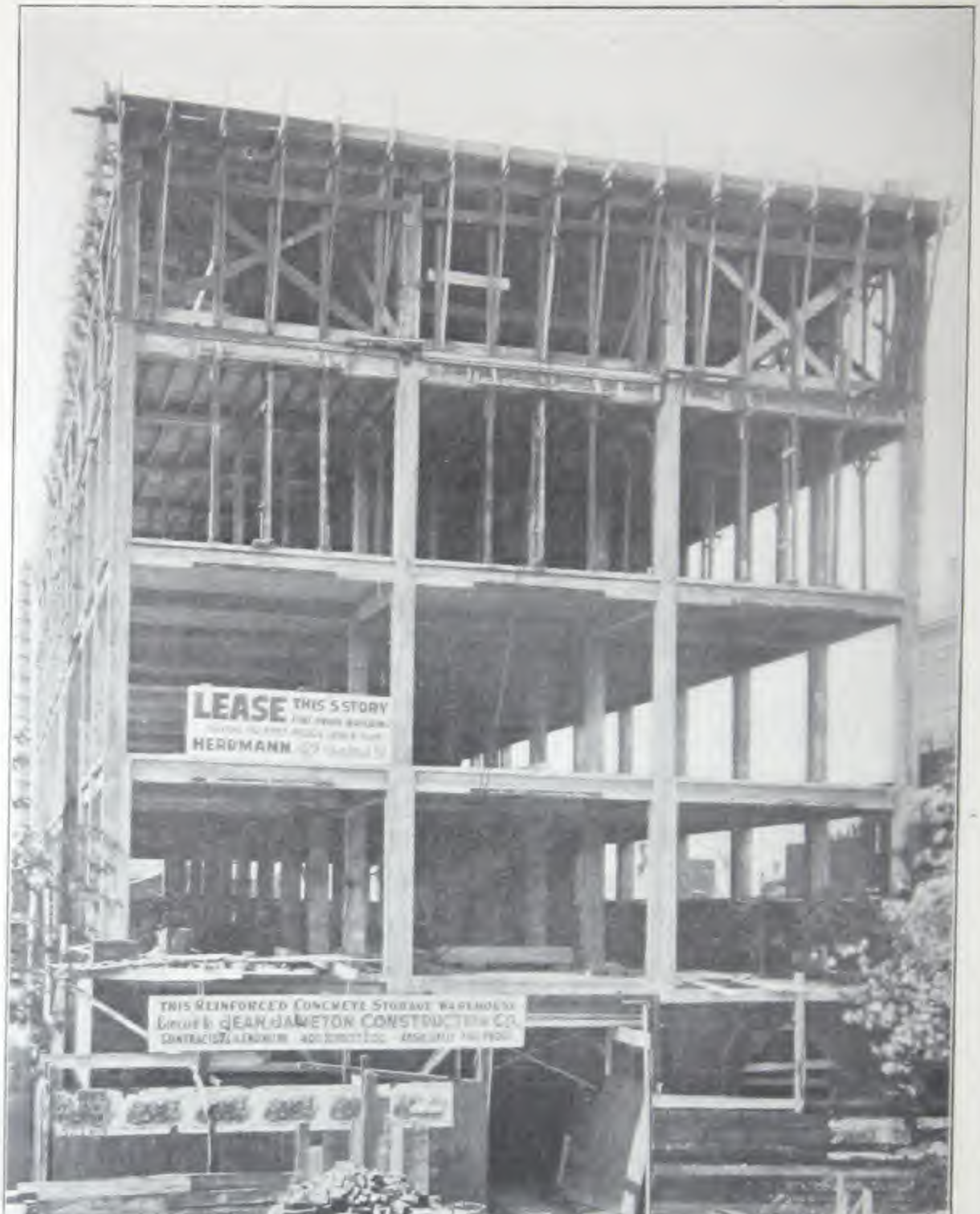


JOPLIN TRANSFER CO.'S BUILDING,

Joplin, Mo. Messrs. GARSTANG & RAE, Architects

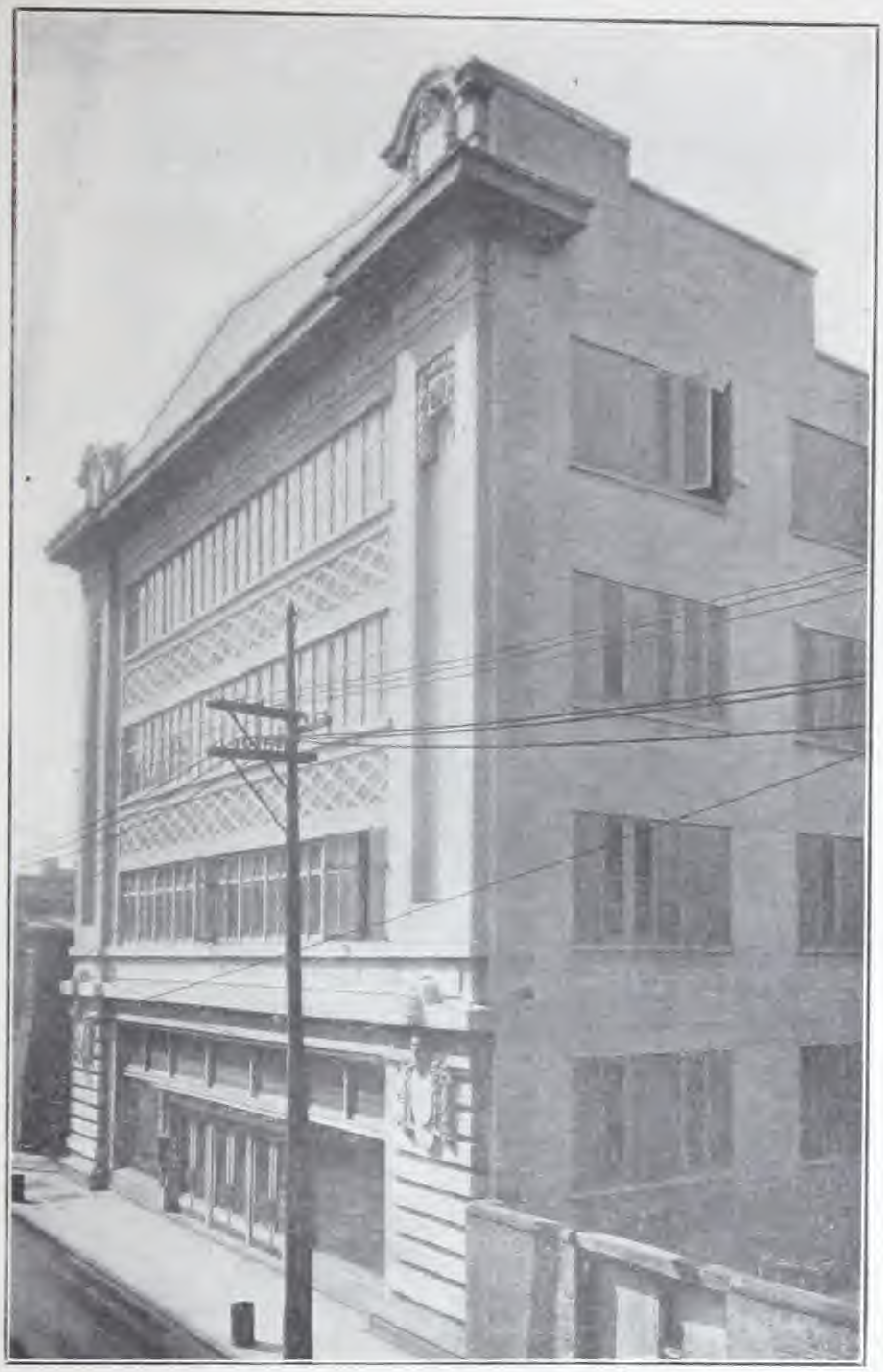
MODOCK BUILDING, ST. LOUIS, MO.

Armored Concrete skeleton construction.



FIREPROOF HOTEL, ST. LOUIS, MO.

All floors, roof and beams supporting walls, of Armored Concrete.



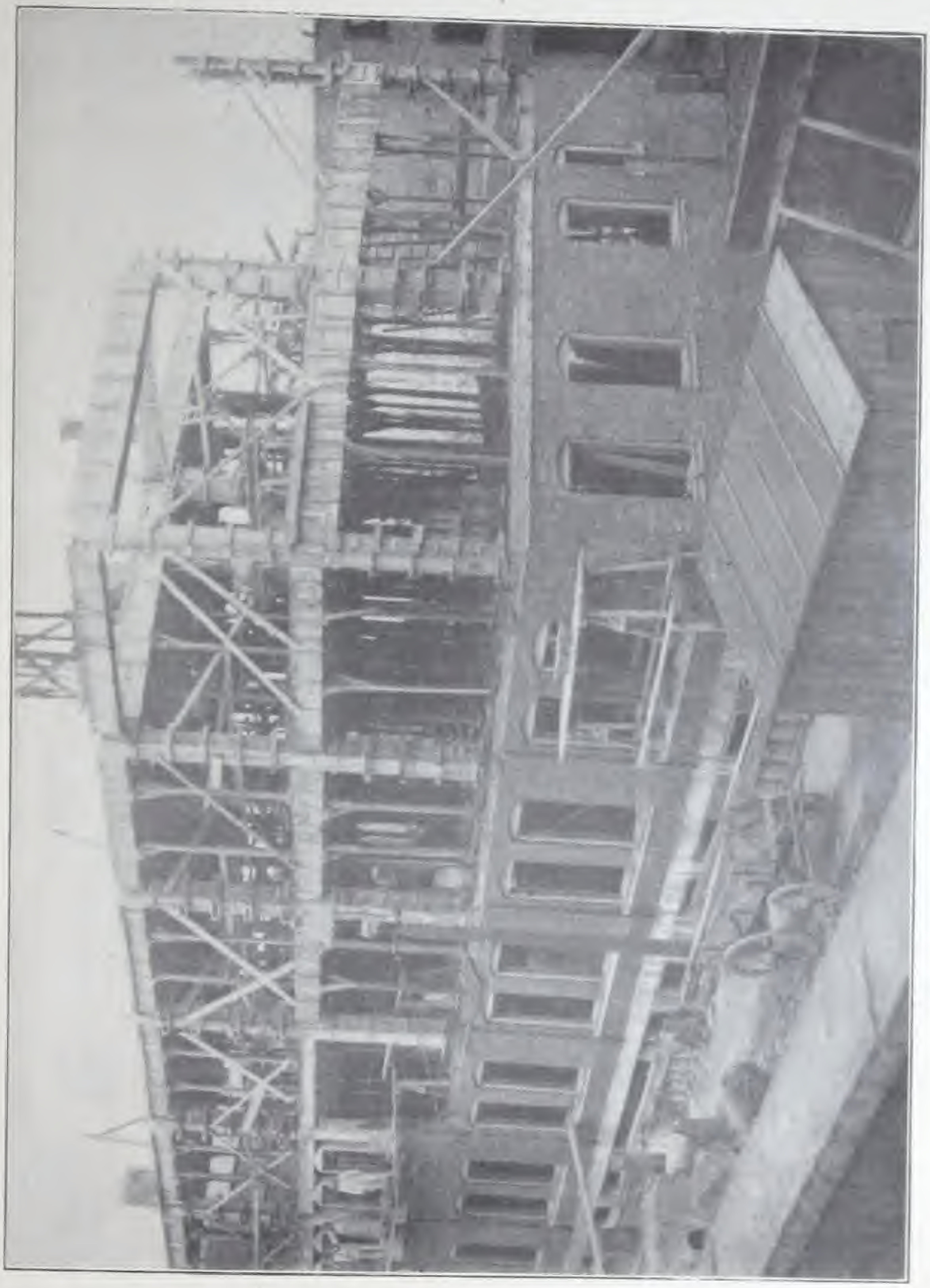
PEERLESS LAUNDRY BUILDING.

Mobile, Ala. Mr. GEO. B. ROGERS, Architect

This entire building, including footings, columns, walls, floors, roofs, stairs, smoke stack and partitions around elevator and ventilation shafts is constructed of Armored Concrete, Hennebique System. The girders in the front wall have a clear span of 50 feet. The stucco finish on the front wall is applied directly to the rough concrete. The side walls are but 4 in. and left as they came from the frames.

BRIDGE OVER N. J. C. R. R., BAYONNE, N. J.

Through girder bridge of 67 ft. span and 16 ft. overhang; railings forming supporting girders.



74 Irving St., Brooklyn, N. Y.

LEHN & FINK LABORATORY.

Messrs. MAYNICKE & FRANKE, Architects

Skeleton construction in Armored Concrete.

RE-INFORCED CONCRETE WATERPROOF CELLAR.

Keyser Office Building, Baltimore, Md. Messrs. WYATT & NOLTING, Architects

The water level is 11 feet above the cellar floor.

Our system was successfully installed after an unsatisfactory attempt made by a firm using "patented bars."

ARMORED CONCRETE CHIMNEY.
74 Irving St., Brooklyn, N. Y.
Messrs. MAYNICKE & FRANKE, Architects

KEYSER OFFICE BUILDING, BALTIMORE, MD.
MESSRS. WYATT & NOLTING, ARCHITECTS.

BALTIMORE, February 25, 1907.

HENNEBIQUE CONSTRUCTION COMPANY,
1028 Witherspoon Building, Philadelphia, Pa.

GENTLEMEN:

We are in receipt of yours of the 16th inst. In connection with the waterproofing of the Keyser Office Building, we are glad to say that up to the present time no failure in the waterproofing system of any consequence has developed, and we think it safe to assume that the system of waterproofing, and the re-inforcement, which you placed in the basement of this building has proven effective, and that we will have no trouble therefrom.

Very truly yours,

WYATT & NOLTING.

VAN ANTWERP BUILDING,

Mobile, Ala.

GEO. B. ROGERS, Architect

This 12-story store and office building is of Armored Concrete skeleton construction. The structure had to be partly erected on one-half of the lot to allow the owners to move temporarily from an old building on the other half without interfering with their business. As soon as the level of the first part was reached work was carried on over the entire area.

DUFFERIN CHANNEL BRIDGE.

Niagara Falls, Ont. Messrs GARSTANG & RAE, Architects

This electric highway bridge has a clear span of 50 feet.

BRIDGE IN PRIVATE ESTATE.

Menands, N. Y. FULLER & PITCHER, Architects

ALBANY CITY HOMEOPATHIC HOSPITAL AND DISPENSARY,

North Pearl St., Albany, N. Y. — Mr. M. T. REYNOLDS, Architect

All structural parts of re-inforced concrete. The building was erected on sloping ground of a clay formation. A re-inforced concrete slab, laid directly on the soil and stiffened by beams and girders, distributes the total weight of the building, uniformly over the entire area.

STABLE FOR MESSRS. WENDELL & EVANS,

23-27 Morton St., N. Y. City.

Mr. WM. HIGGINSON, Architect

View showing the architectural treatment of the front wall.

VIEW OF STALLS

There are stalls for 92 horses in the building, the partitions for which are of concrete 2 in. thick with 6 in. posts.

This 4-story and basement stable is constructed throughout of re-inforced concrete, including all footings, walls, columns, beams, floors, roof, stairs, runway and partitions. The fire insurance rate for this Armored Concrete Building is but **23 cents** for the building, and **77 cents** per hundred for the contents.

STORAGE BUILDING FOR THE METROPOLITAN LIFE INSURANCE CO.

Bronxville, N. Y. Messrs. N. LE BRUN & SONS, Architects

GENERAL VIEW.

Footings, columns, beams, lintels, floors, roof and stairs of Armored Concrete. All floors are designed to carry 400 lbs. live load per sq. ft.

CANTILEVER AT WORLD'S FAIR, ST. LOUIS, MO.

This was a special construction consisting of a cantilever arm of 32 ft. overhang. It showed the possibilities of Armored Concrete and its reduced dimensions in comparison with the steel. The total width of the section at the greatest bending moment is but 2 ft. whereas a width of 3 ft. would have been necessary in the case of a steel structure.

This construction was loaded to destruction and the result of the tests corroborated the assumptions of the calculations.

BRIDGE AT ALLEGHENY, PA., CROSSING THE 4-TRACK LINE OF THE P. R. R. CO.

Messrs. PRICE & McLANAHAN, Architects.

GENERAL VIEW.

McKINLEY NATIONAL

MEMORIAL.

CANTON, OHIO.

H. VAN BUREN MAGONIGLE,
Architect

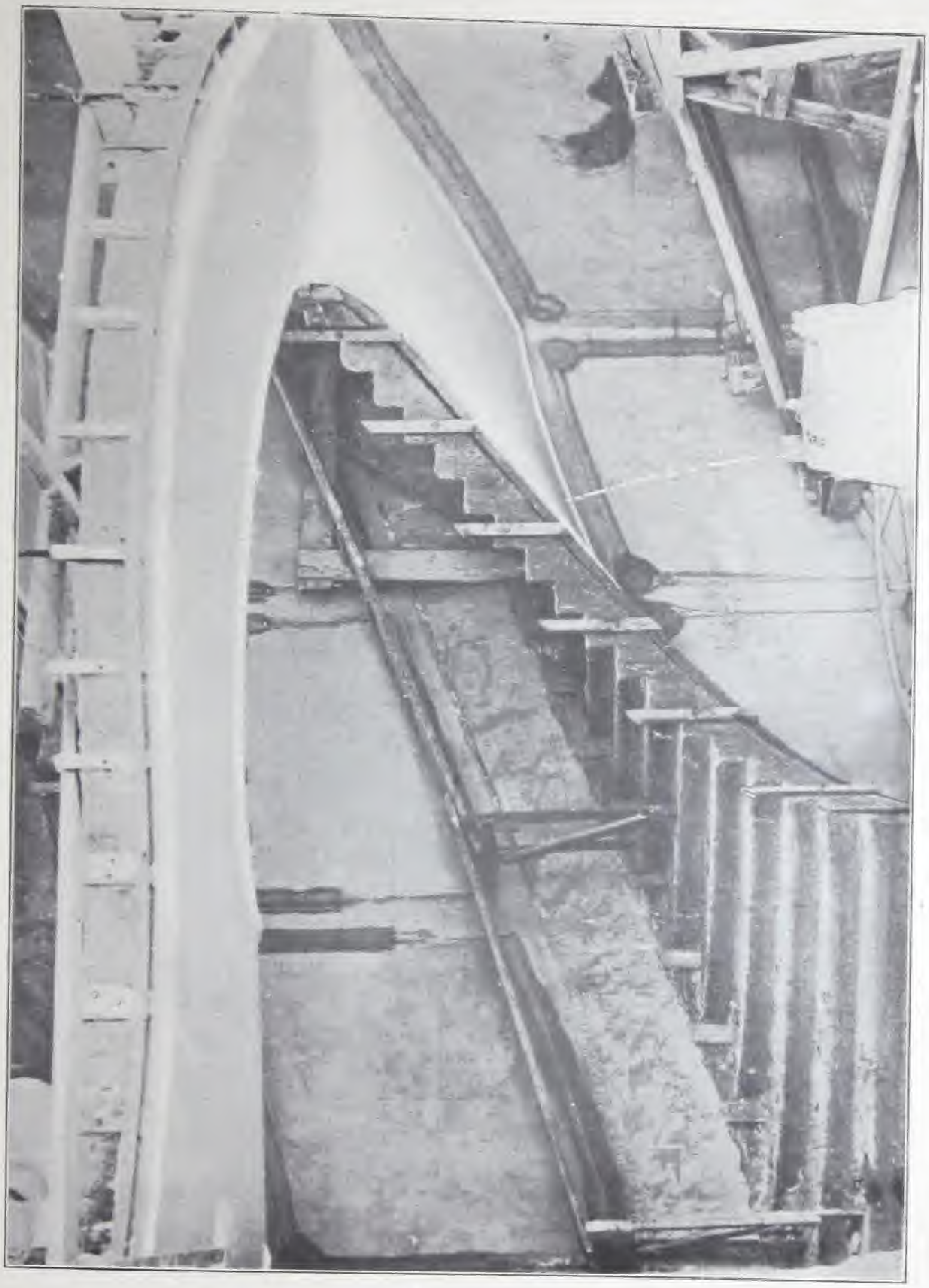
All the foundations and structural parts supporting the granite work in this Memorial are in Armored Concrete.

VIEW SHOWING THE MASSIVE GRANITE BLOCKS BEING LAID ON STEPPED ARMORED CONCRETE BEAMS TO FORM THE APPROACHES.

CAR BARN, UNION TRACTION COMPANY, QUAIL ST., ALBANY, N. Y.

Footings, columns, beams and the 37,700 sq. ft. of roof are constructed of Armored Concrete. JOHN DYER, JR., Builder

Note the light column construction; ratio of diameter to length is 1 to 27.



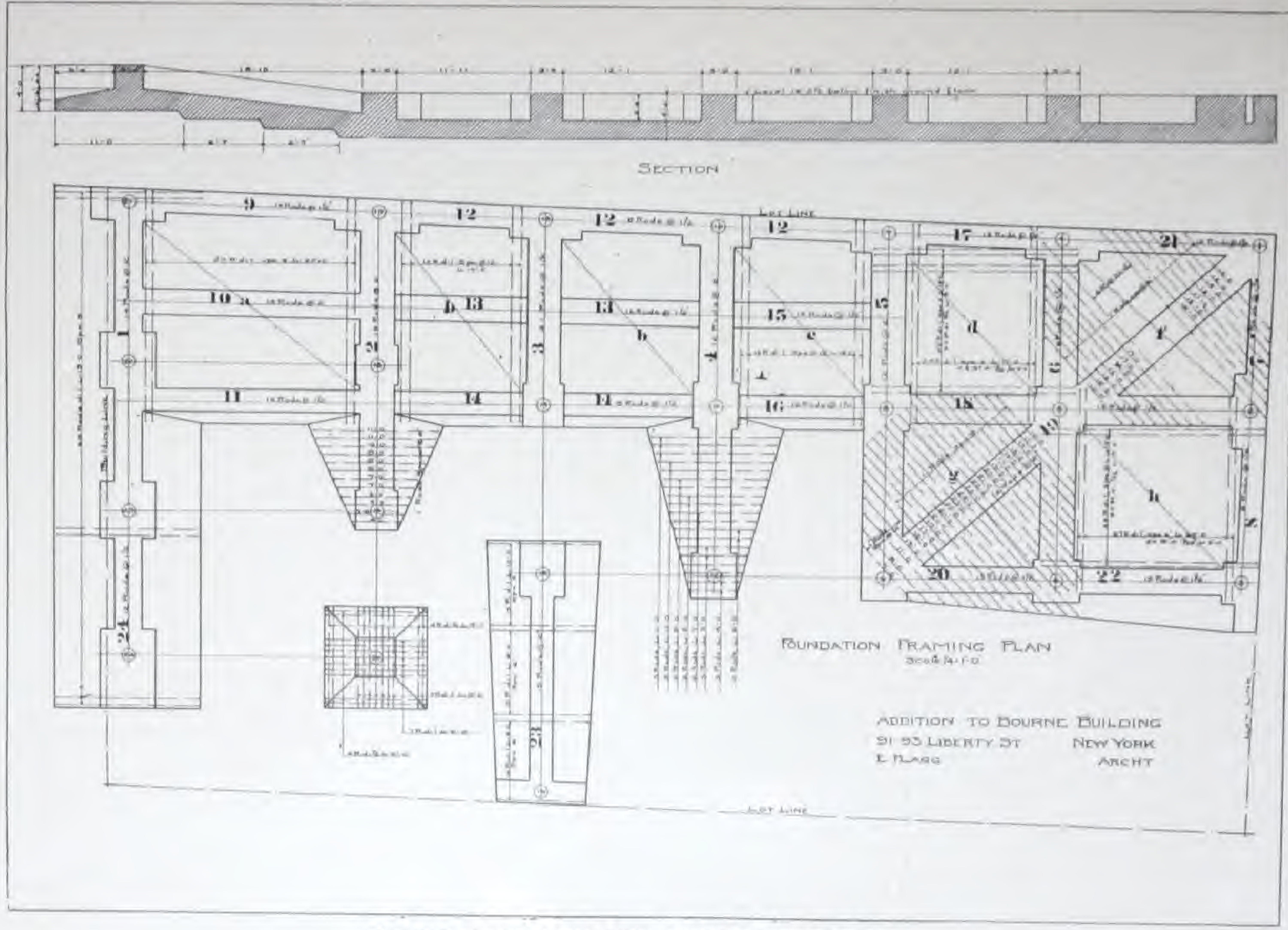
STAIRS IN A NEW YORK CITY RESIDENCE.

These stairs strikingly illustrate the possibilities of Armored Concrete in bold and unusual designs. Mr. C. H. GILBERT, Architect.

EXPOSITION BUILDING OF THE ASSOCIATION OF AMERICAN-PORTLAND CEMENT MANUFACTURERS AT WORLD'S FAIR, ST. LOUIS, MO.

MAURAN & RUSSEL, Architects

The building is entirely in concrete, walls being only 4 in. thick. Note the appearance of the outside walls, which was accomplished by brushing the concrete when it was still green.



FOUNDATION FOR THE BOURNE BUILDING,

91-93 Liberty St., New York City. ERNEST FLAGG, Architect

As the SINGER Building with deep caisson foundations was to be erected on adjoining land, extreme care was necessary in designing the foundations for the BOURNE Building. A re-inforced concrete "raft construction" was used with a great saving of both time and expense over the usual methods. It proved entirely satisfactory.

RETAINING WALL, CINCINNATI HOSPITAL.

In course of construction.

RETAINING WALL, CINCINNATI GENERAL HOSPITAL.

Cincinnati, Ohio.

Messrs. SAMUEL HANNAFORD & SONS, Architects

Height, 26 feet. Thickness of wall and buttress, 6 inches.

Princeton, N. J. **DORMITORY BUILDING, PRINCETON UNIVERSITY.** Mr. B. W. MORRIS, Architect

All structural parts in Armored Concrete.

Sherbrooke, Canada. SHERBROOKE HOSPITAL. CH. CHAUSSE, Architect

The three aisles and the administration building are connected through a central tower.

FORT WAYNE PASSENGER STATION, ALLEGHENY, PA.

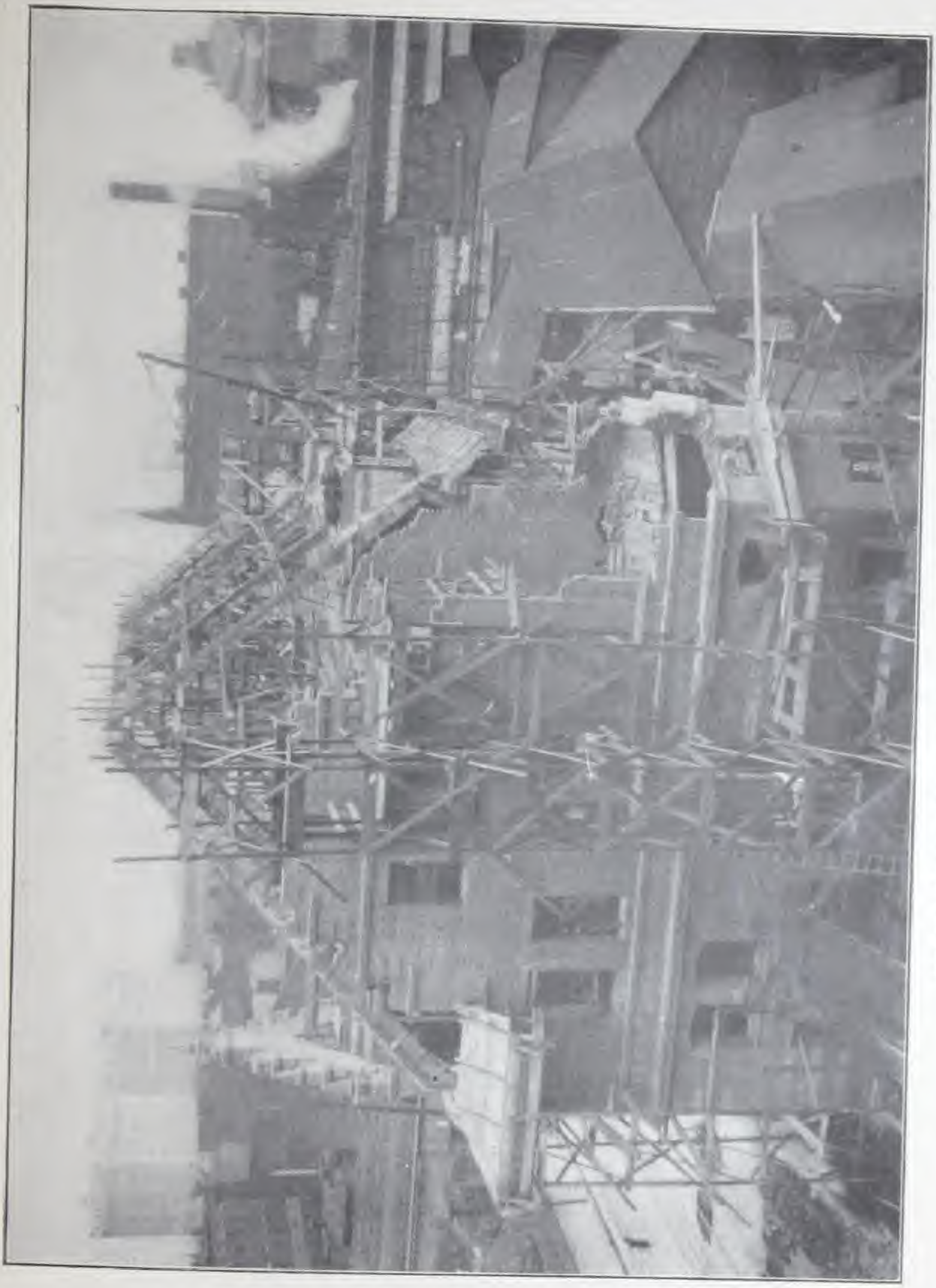
ARCHITECTS: PRICE & MCLANAHAN.

All structural parts (foundations, columns and stairs), in the Hennebique System.

Note the 50 ft. span roof truss.

The Concourse is also in Armored Concrete; all surfaces are finished in cement of a light color.

GENERAL VIEW.

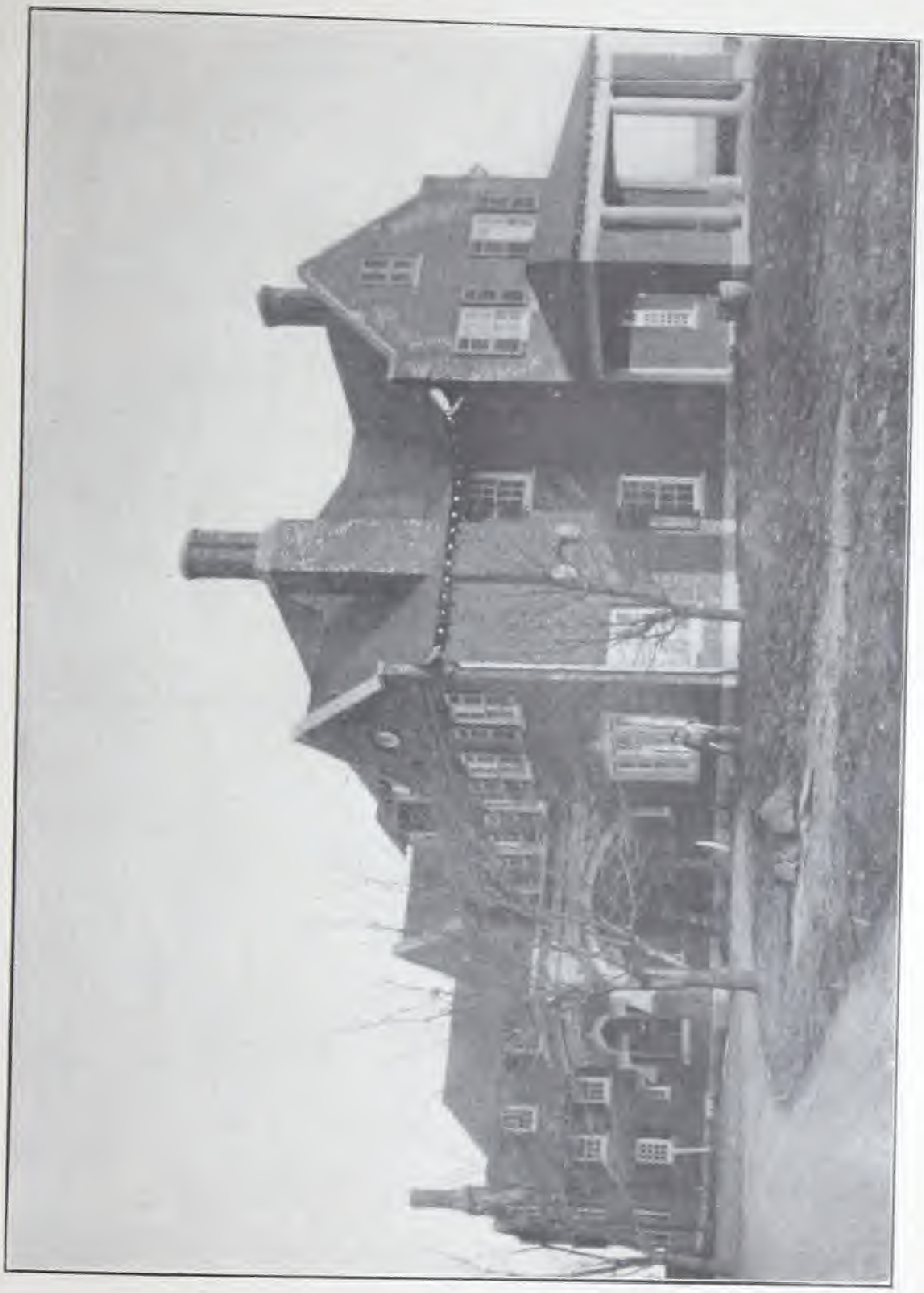


FORT WAYNE PASSENGER STATION, ALLEGHANY, PA.

View showing construction of the fifty-foot span roof trusses.

Brooklyn, N. Y. **BROOKLYN INSTITUTE.** McKIM, MEAD & WHITE, Architects

View showing construction of supports for heavy stone steps and piers, some of which weighed 30 tons.
The foundations were on poor soil.



McKEAN RESIDENCE.

Rosemont, Pa. Mr. G. B. PAGE, Architect

The complicated gable roof and all the structural parts are of Armored Concrete.

Cincinnati, O. **FIRST INTERMEDIATE SCHOOL.** Mr. E. H. DORNETTE, Architect

Floors and Roof Entirely of Armored Concrete. Spans, 32 ft. and 40 ft.

LONG ISLAND COLLEGE HOSPITAL.

Brooklyn, N. Y. Mr. D. EVERETT WAID, Architect

View showing East Wing of Building B. Solarium Roof, Amphitheatre and Stairs are also in Armored Concrete, their surfaces being finished in artificial stone.

COAL BUNKER

IN OLIVER IRON & STEEL CO.'S PLANT

Pittsburg, Pa.

22 ft. wide—13 ft. 6 ins. deep. Capacity 8 tons per running foot.

LEATHER GOODS FACTORY

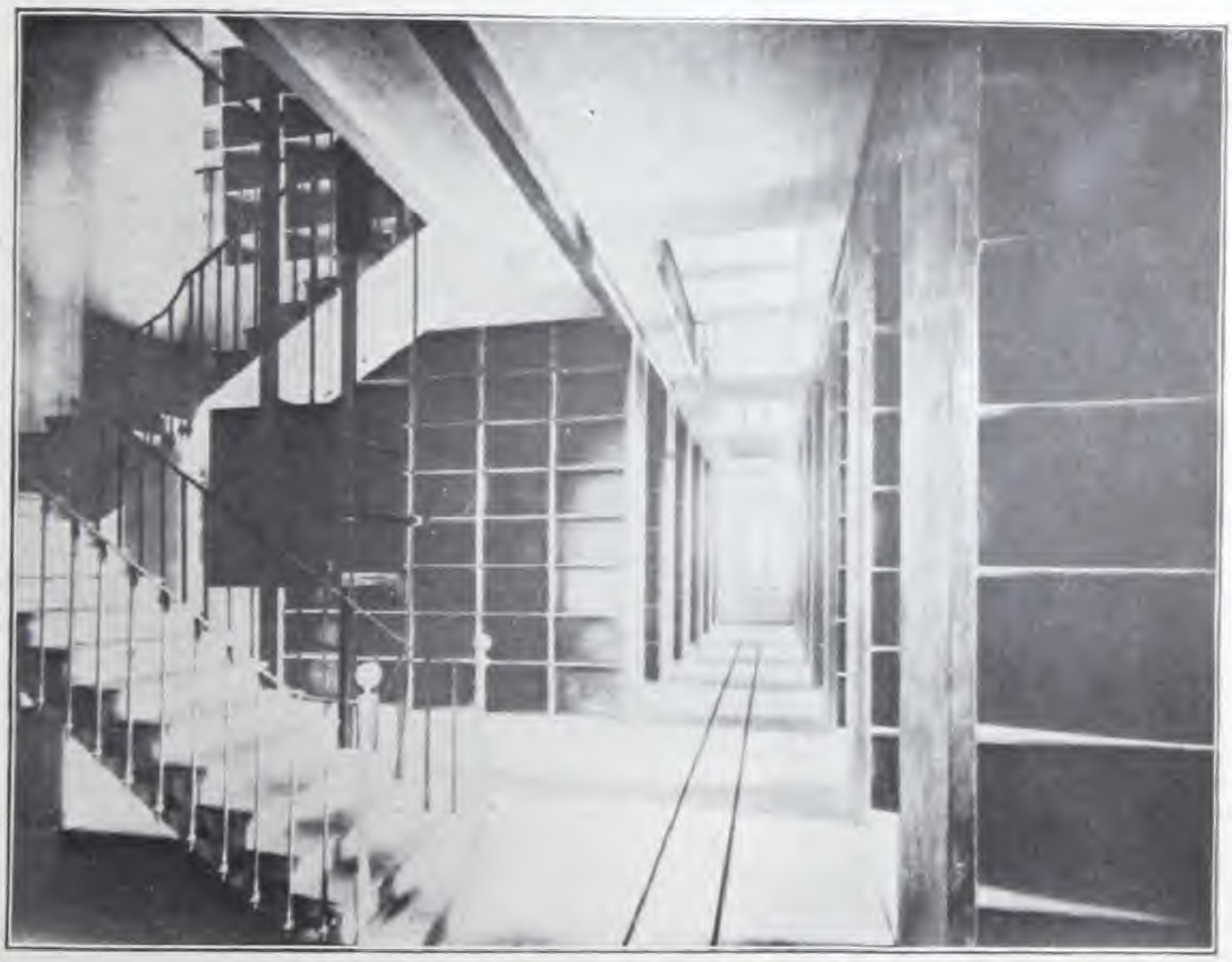
JOHN MEHL CO.

Jersey City

MR. WALTER KIDDE, Architect

Stamford, Conn. **STAMFORD TOWN HALL.** E. JOSSELYN, Architect

All floors and stairs in Armored Concrete.



FIREPROOF VAULT BUILDING FOR THE ARCHIVES OF THE "COMPTOIR D'ESCOMPTE," AT RUEIL, FRANCE. Interior View.

Walls, roof, stairs and cases in Armored Concrete, Hennebique System.

BANQUET ROOM AT CITY HALL, LORIENT, FRANCE.

The entire skeleton is in the Hennebique System. The roof framing shows how easily Armored Concrete can replace the most difficult steel truss construction. Span 38 ft., 6 ins.

INTERIOR OF THE MUSEUM OF ANTIQUITIES AT CAIRO, EGYPT.
Spans of 32 feet. Ceilings paneled for decoration.

DOME OF THE MUSEUM OF ANTIQUITIES AT CAIRO, EGYPT.
Diameter of Dome, 27 ft. 8 in. The exterior surface is copper flashed. Thickness of walls, 5 in.

VILLA AT BOURG LA REINE, FRANCE.

The walls in concrete are formed by cast blocks set in place the same as cut stone. The tower has a free over-hang of 14 ft. 6 in.

VILLA AT BOURG LA REINE, FRANCE.

WINE VATS AT BORDEAUX, FRANCE.

24 Vats in Armored Concrete, Hennebique System, with a total capacity of 300,000 gallons. The Interior surface is finished with glass plates. The Vats are air-tight so as to resist a high pressure from the pneumatic pumping plant.

CONSTRUCTION OF ARMORED CONCRETE SEWER PIPES IN THE HENNEBIQUE SYSTEM AT LENS, FRANCE.

The sections are manufactured at the plant and shipped to the trench, where they are connected.

STOREHOUSE FOR FELIX POTIN, PARIS, FRANCE.

M. AUSCHER, Architect

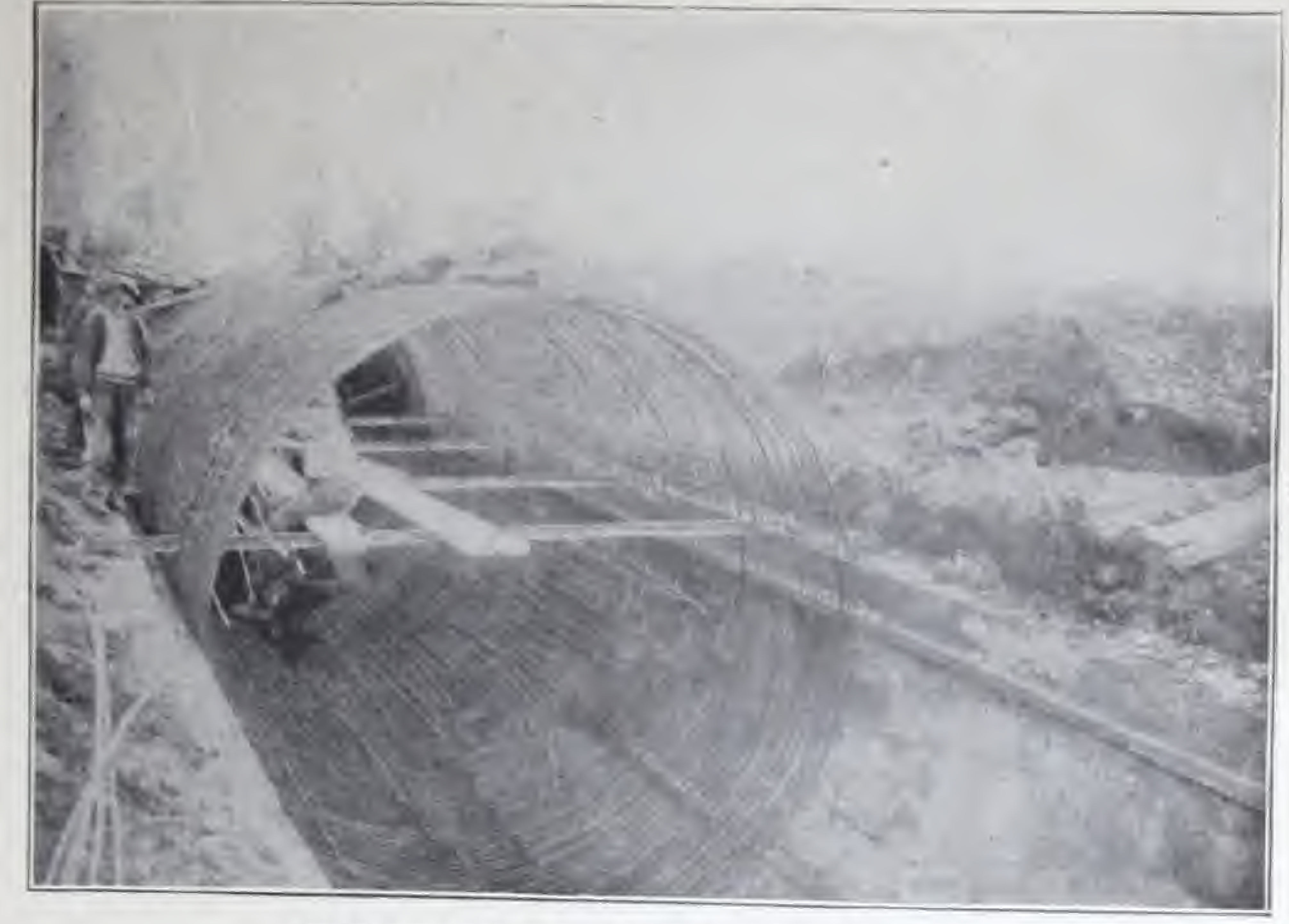
All the floors, roofs, and walls are in Armored Concrete. The veneer of the lower 4 stories walls is of cut stone.

SAXBY SWITCH TOWER AT JOINVILLE, LE PONT, FRANCE.

Railroad guard tower. Walls with a thickness of four inches. Flat roof. Foundations are of enlarged width, to give greater stability.

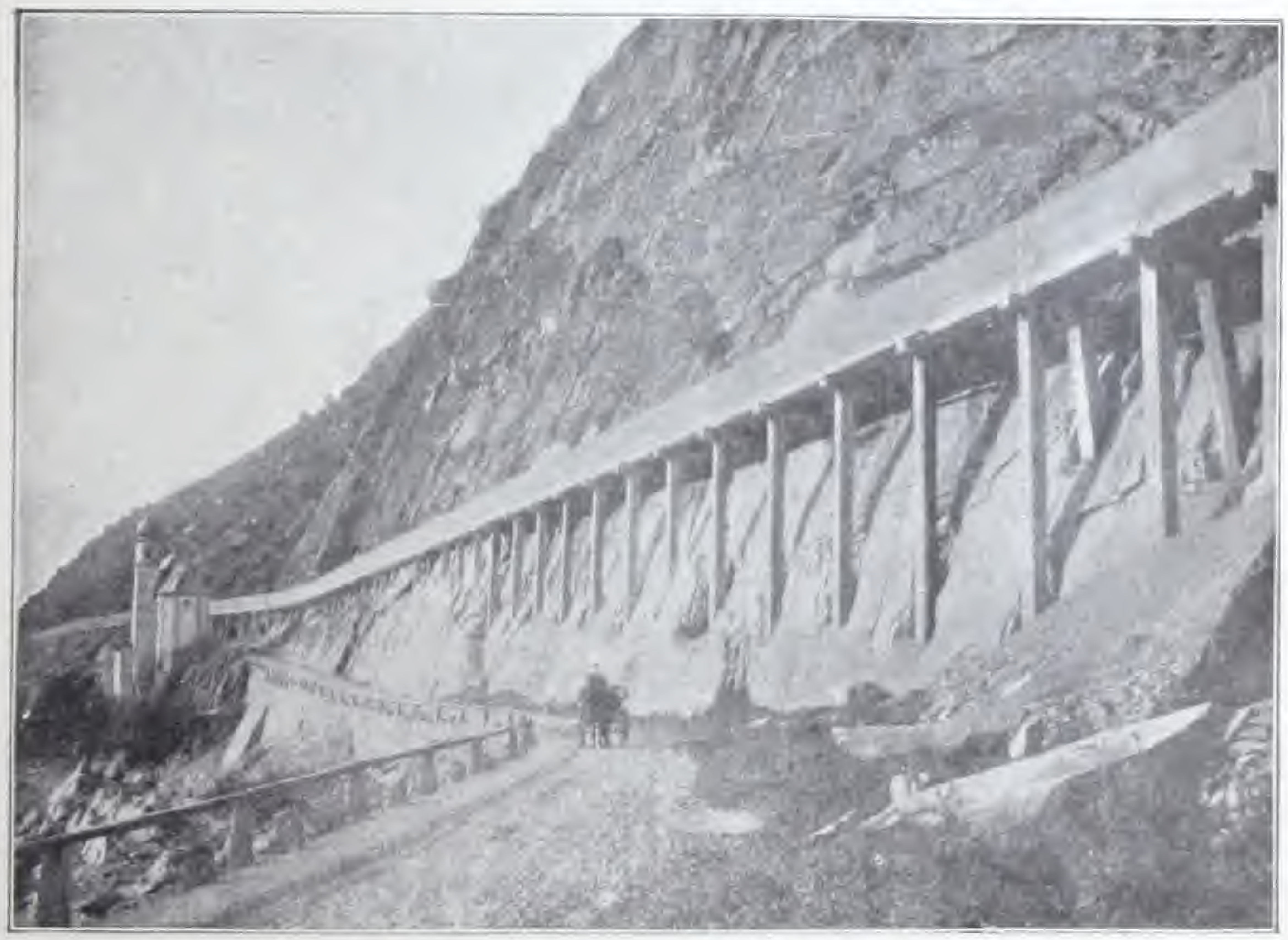
EXPERIMENTAL FRACTURE OF A TROLLEY POST IN ARMORED CONCRETE, HENNEBIQUE SYSTEM.

Post, 20 feet high. The illustration indicates the method of testing. A lateral force of 2,500 lbs. is applied at the top. The post readily resumes its normal position upon the removal of the applied stress.



PENSTOCK OF GRENOBLE, FRANCE.

Diameter, 10 ft. 6 in. Maximum head of water, 65 ft. Absolutely water tight, with no special waterproofing material except cement.

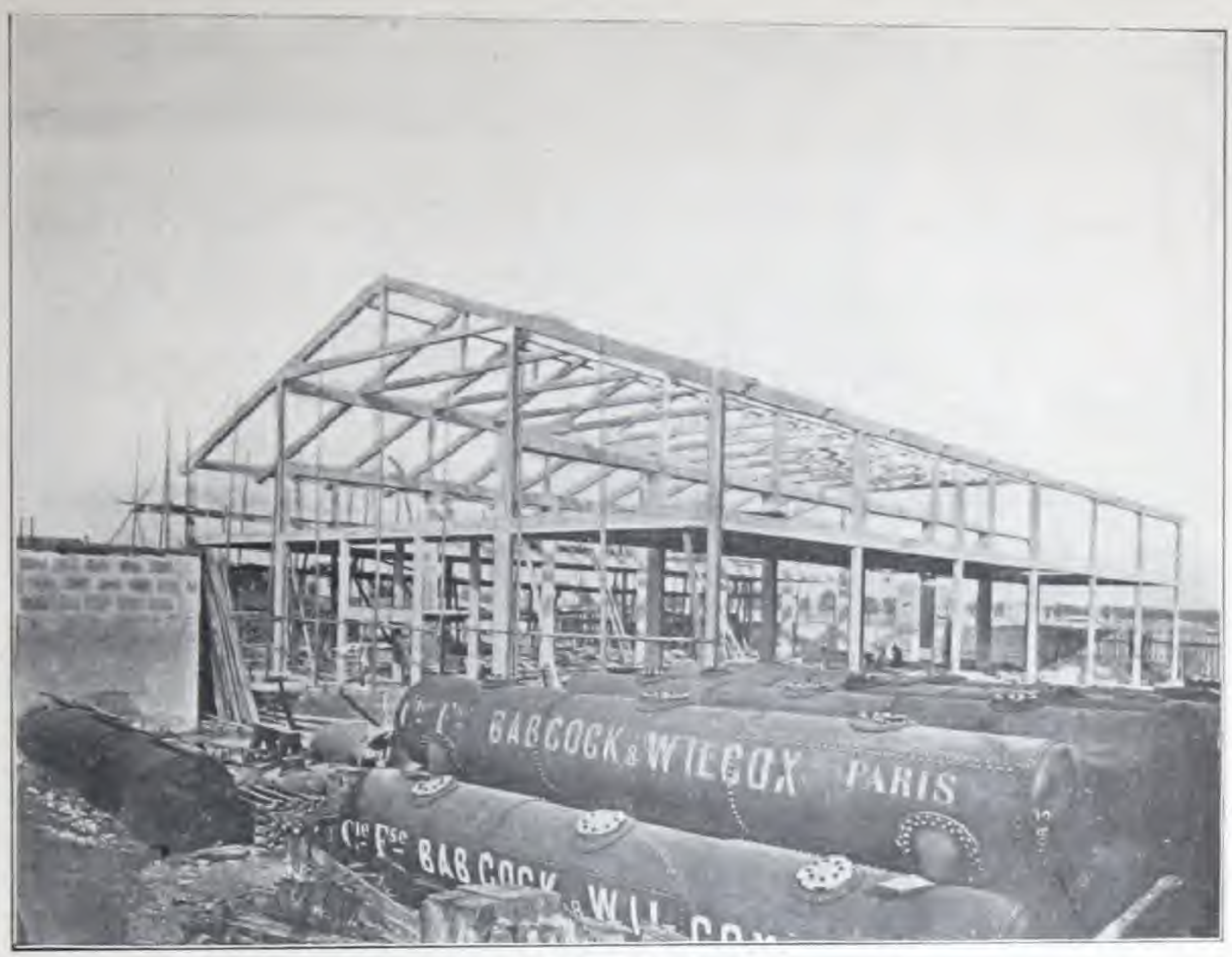


CANAL OF THE SIMPLON.

Clear section, 6 ft. 4 inches by 6 ft. 4 inches. Length, 10,200 running feet. Concrete posts support the Canal.

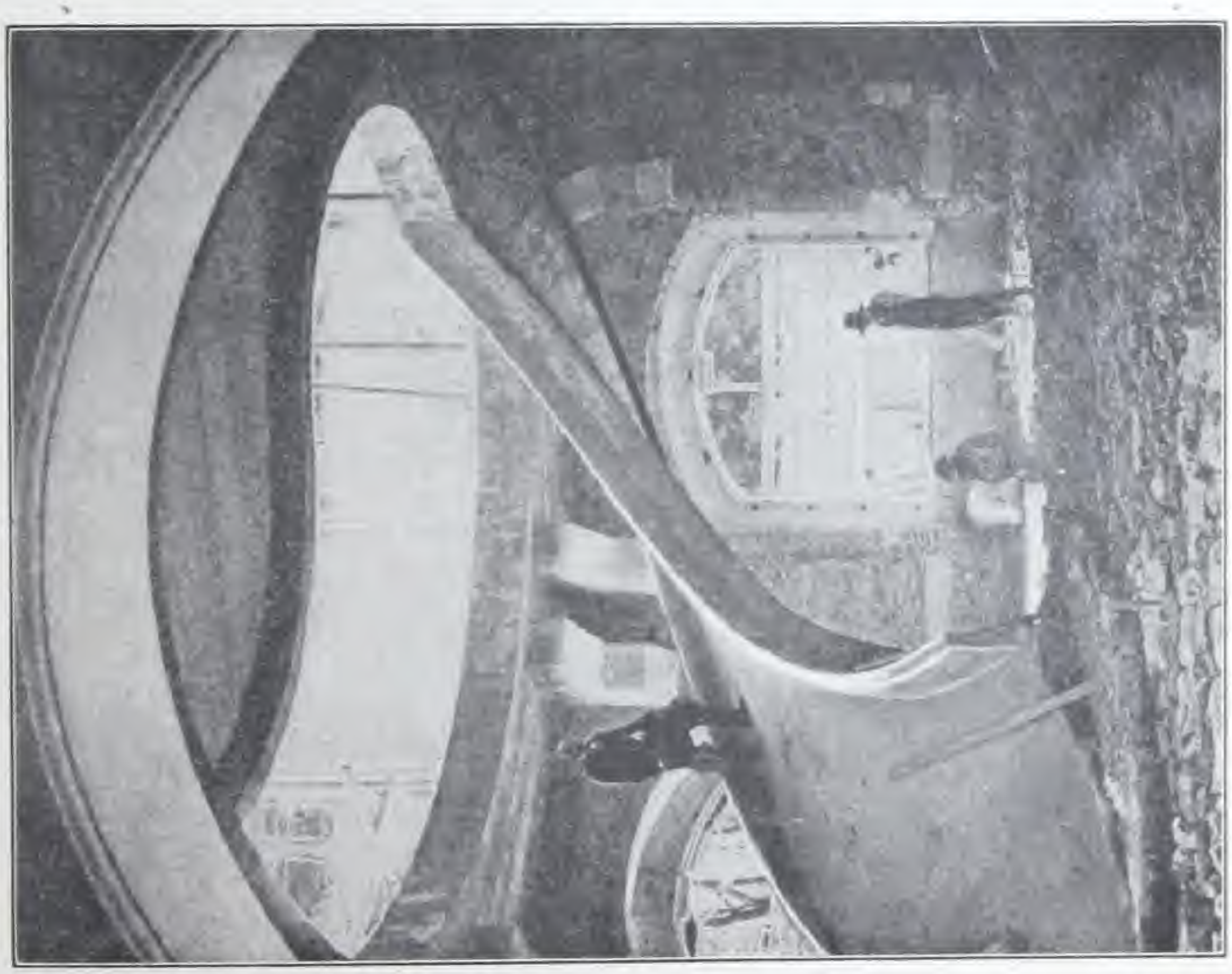
WATER TANK AT EKATERINOSLAW, RUSSIA.

Two Water Tanks on Armored Concrete Trestles. Total height of the construction is 102 feet.



FOUNDRY OF BABCOCK & WILCOX, PARIS, FRANCE.

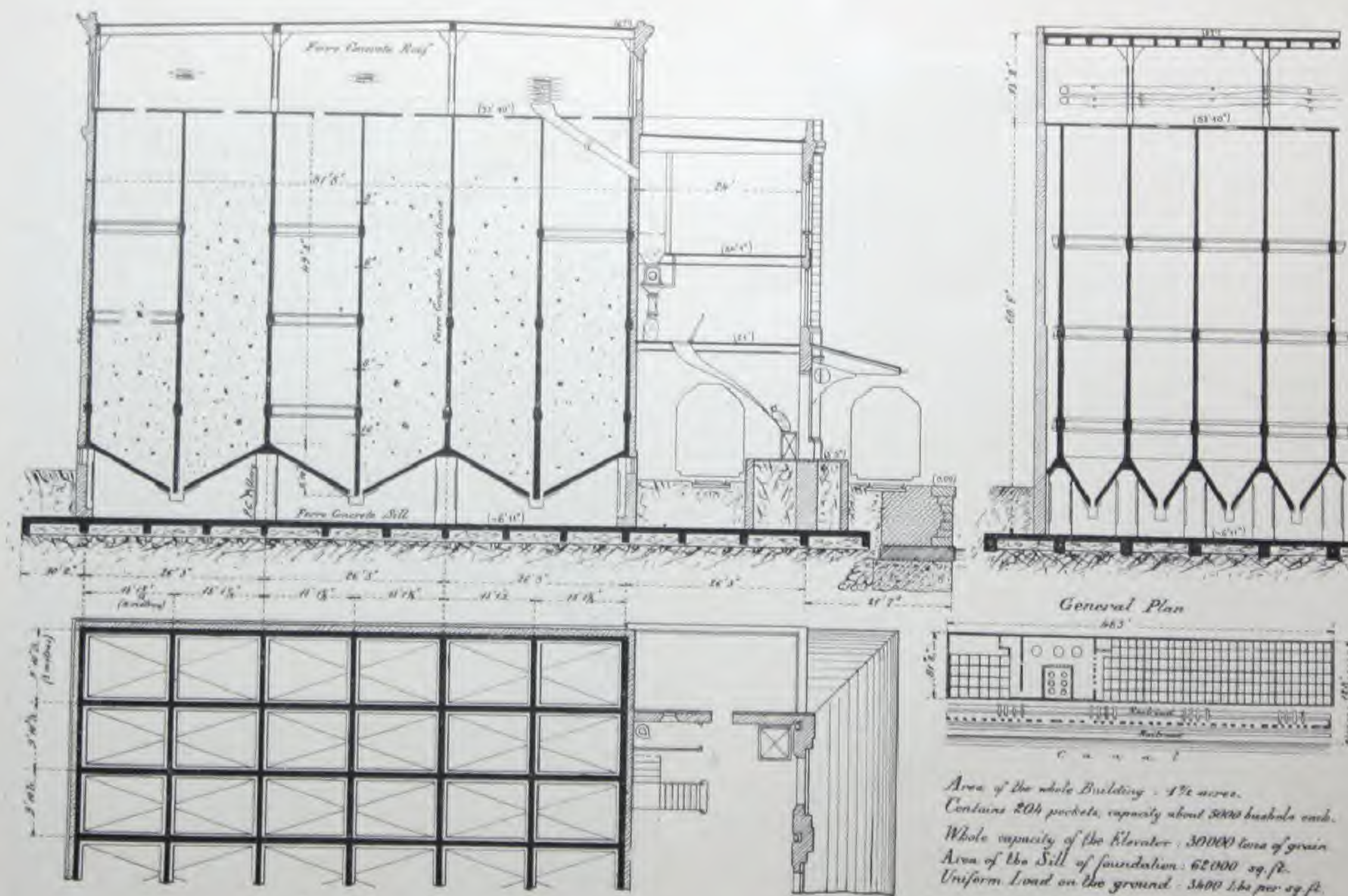
Roof trusses of 40 ft. span, carrying a slate roof. Floor designed for 400 lbs. live load per square foot.



WINDING STAIR AT THE PETIT PALAIS DE BEAUX ARTS, PARIS.

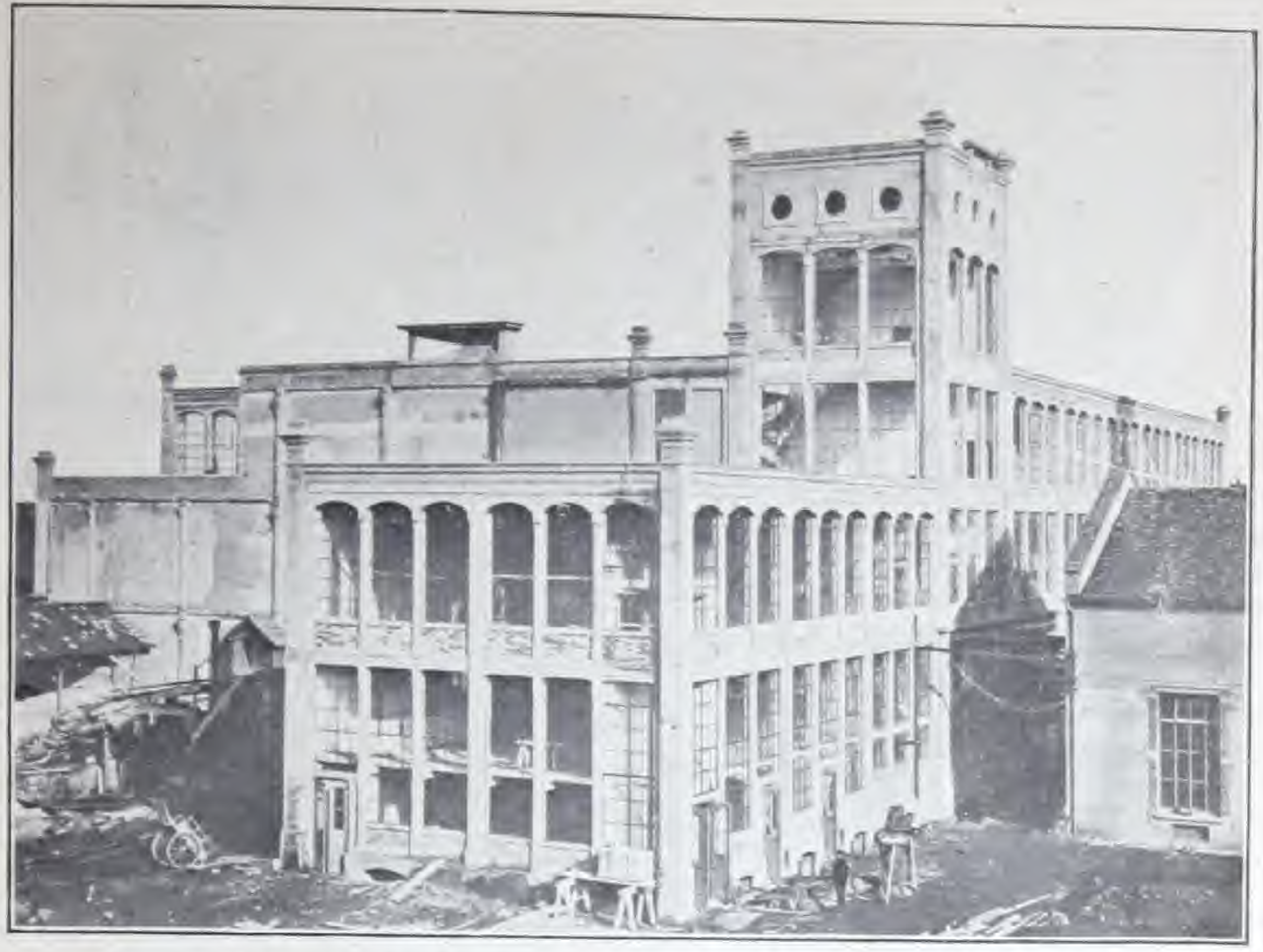
Mr. GIROD, Architect

This stair is only supported at floor levels and winds 180°



GRAIN ELEVATOR AT GENOA, ITALY.

Elevator 63 feet high, resting on foundation plate, 500 × 83 feet. This elevator was built in 8 months.



"LA CITE" SPINNING MILL, MULHOUSE, ALSACE. **Exterior View**

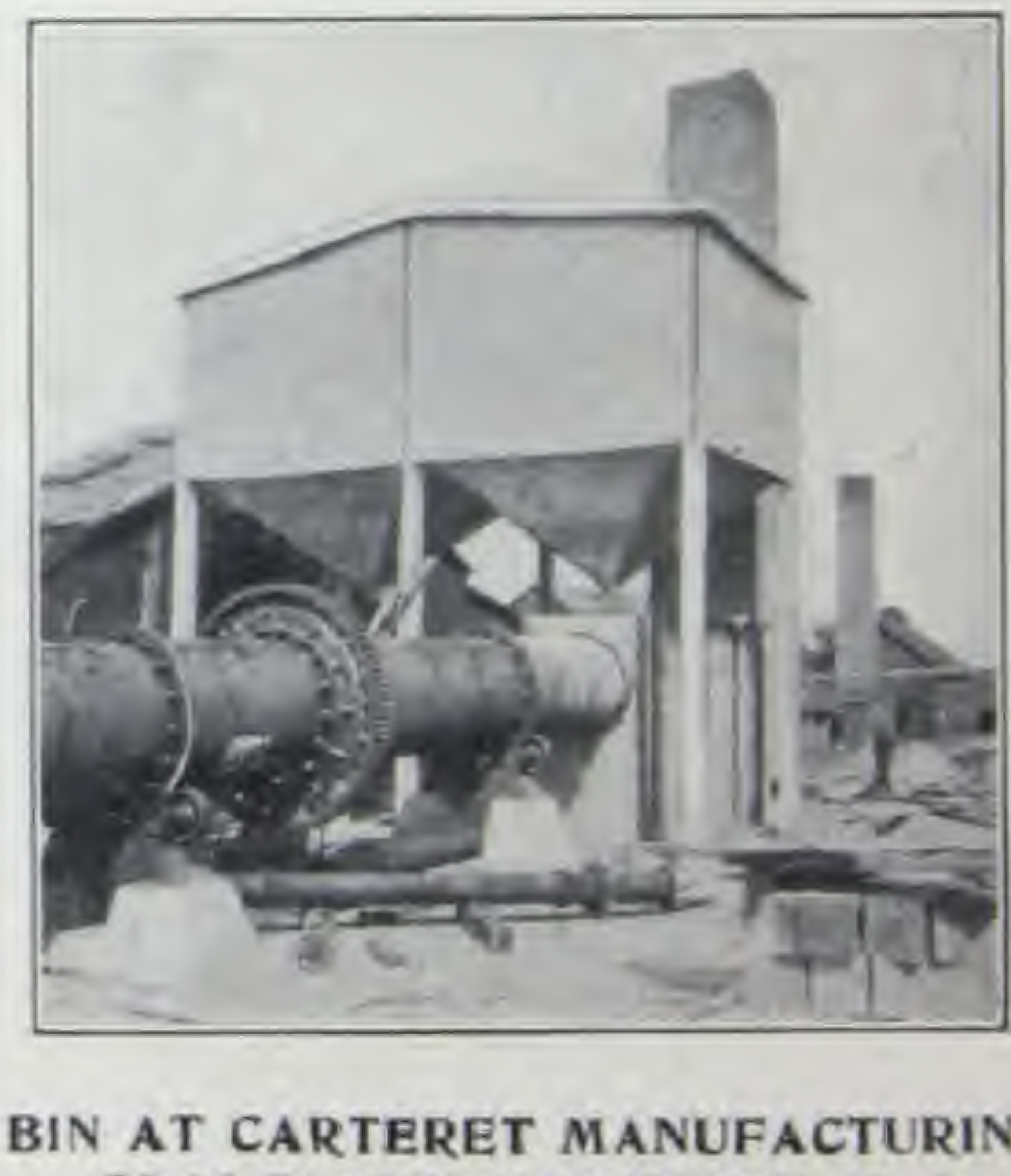
Walls in Hennebique System. Large area of window space.

"LA CITE" SPINNING MILL. **Interior View.**

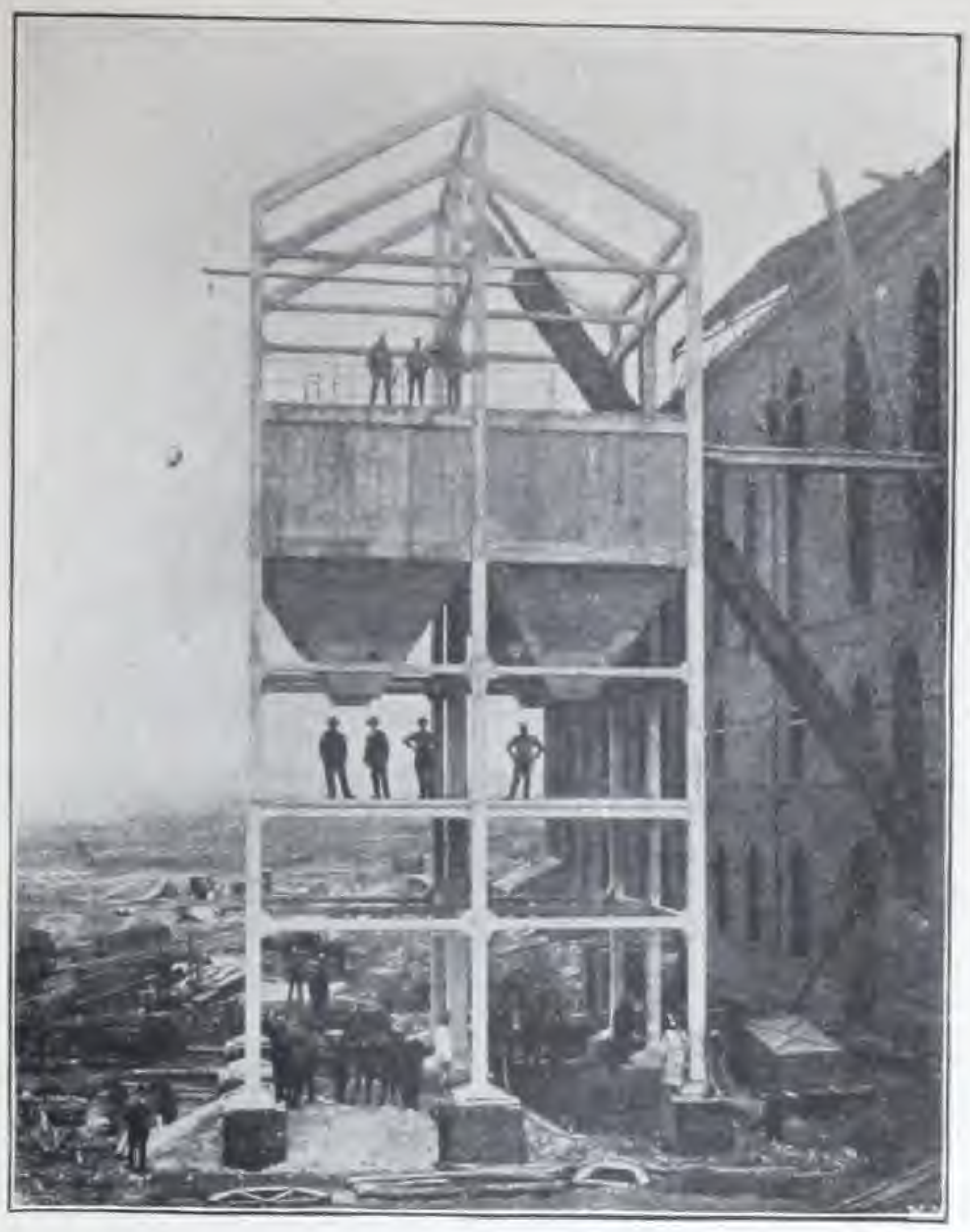
Spinning hall, 160 x 162 feet, To provide an abundance of light, the exterior uprights are also in Armored Concrete, thereby affording a maximum window area. Distance between columns, 21 feet. Transmission support in Hennebique System, constructed at the same time as the floor; in this way all vibrations are avoided.

COAL POCKETS, 450 TONS CAPACITY, AT LENS, FRANCE.

ASH BIN. DAUPHIN STREET POWER STATION, PHILADELPHIA.
RAPID TRANSIT CO.
16 ft. cubical bin resting on Armored Concrete Columns.

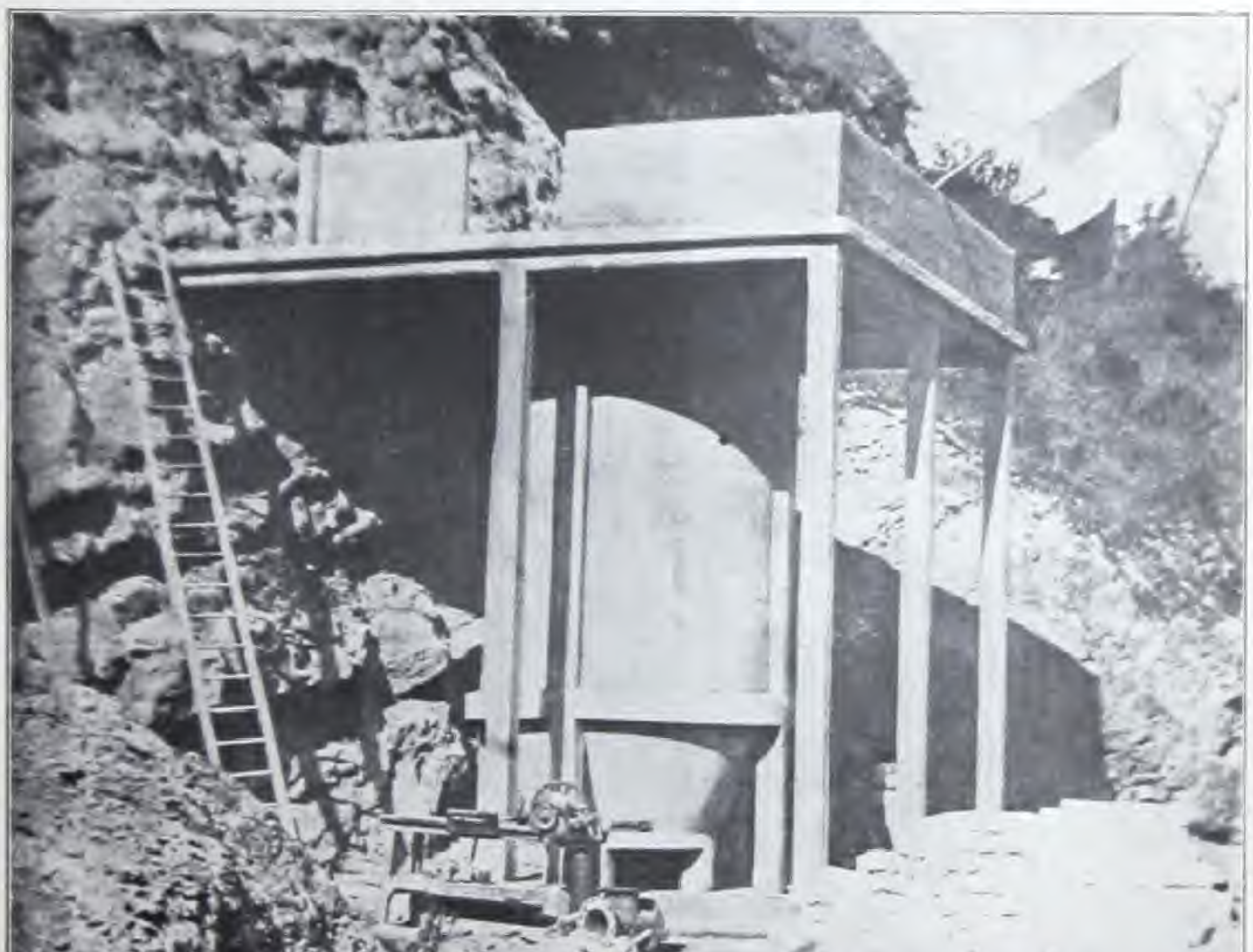


BIN AT CARTERET MANUFACTURING CO.'S PLANT, CARTERET, N. J.



COKE BINS AT ANICHE, FRANCE.

Capacity of each bin, 50 tons. Height above ground, 40 feet. Columns, ties and footbridge are all in Armored Concrete, Hennebique System.



LIME KILN AT LUZECH, FRANCE.

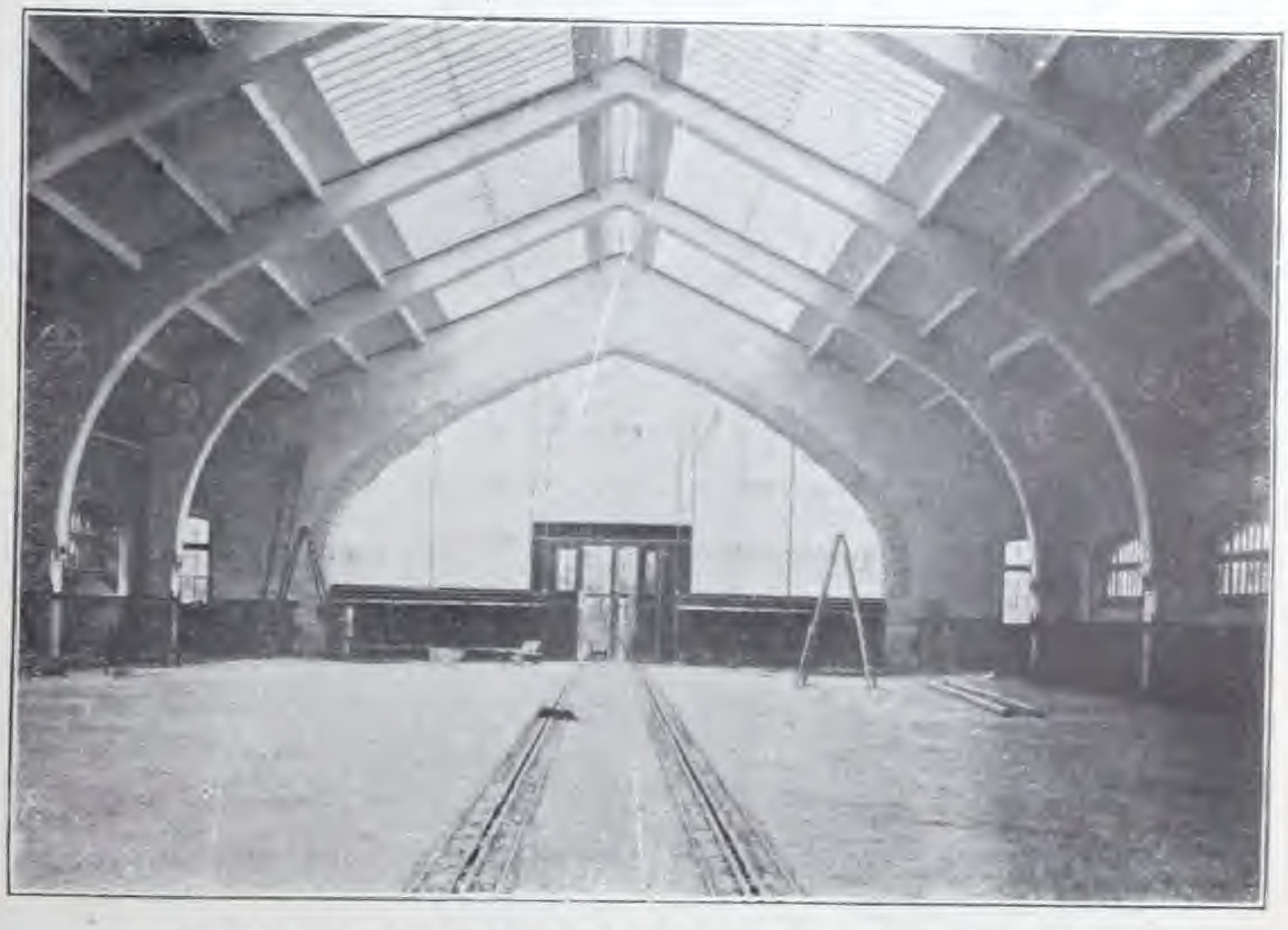
Jacket in Armored Concrete, Hennebique System, wrapping a fire brick furnace. Excepting the direct fire surface, which is of brick and which is subjected to 1800 degrees Fahrenheit, Armored Concrete constitutes all the structural parts of the kiln.

WATER TOWER, KOBANYA, RUSSIA.

Total height, 112 feet. Diameter of reservoir, 34 feet. Capacity, 93,000 gallons.

AQUEDUCT AT BARGONE, ITALY.

Length, 1520 yards; height, 13 ft. 4 inches; width, 4 ft. 6 inches. Armored Concrete columns spaced at 20 ft. centers, The height of these columns varies with the grade of the land from 6 ft. to 31 ft.



OBERTHUR'S PRINTING FACTORY, RENNES, FRANCE.

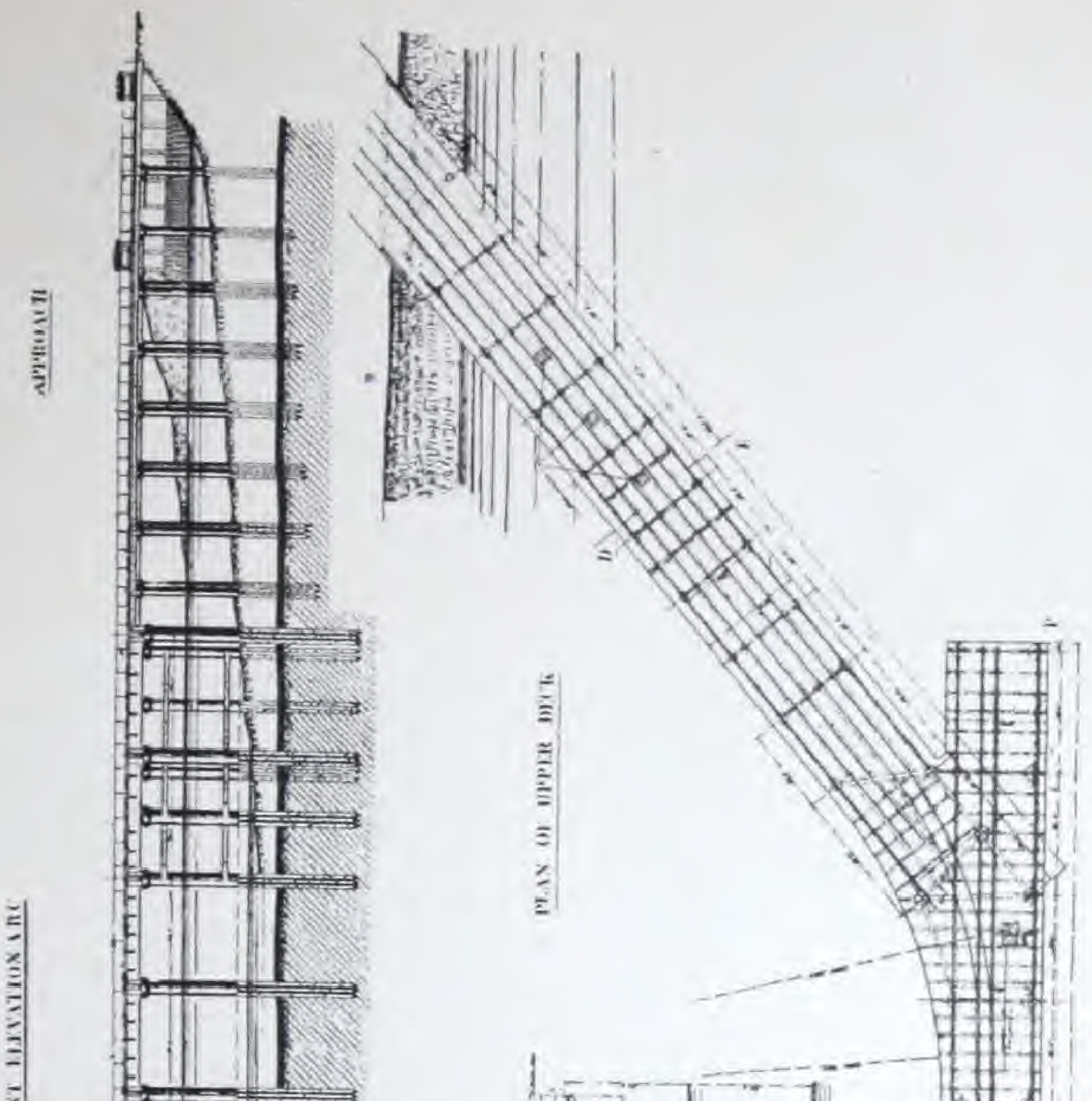
Hall of a span of 83 feet. Concrete roof with skylights.

DAGENHAM JETTY, ENGLAND. **General View.**

Length, 770 feet; width, 36 feet. Piers made with three Armored Concrete Piles in the Hennebique System.

WHARF IN CANTILEVER AT THE MILLS OF NANTES, FRANCE.

Cantilever of 11 ft. resting on Concrete Piles and anchored to the building which is also built in Armored Concrete. The photograph gives a view of this construction during the tests of the wharf, on which a fully loaded wagon is drawn. No sensible deflection could be observed.



PLAN AND SECTION OF DAGENHAM PIER, ESSEX.

DAGENHAM JETTY, ENGLAND. Hennebique System of Armored Concrete.

DRIVING AN INCLINE PILE AT THE FOUNDATION OF THE NEW UNION STATION, HAMBURG, GERMANY.

Foundations of the New Union Station, Hamburg, Germany, the most modern station in the World. The ground on which the building stands was formerly the bed of a creek, and in order to secure a good bearing surface, it was necessary to drive piles. These were 45 ft. long, 16 inches square, and each one bears 50 tons. They are cast vertically and then driven with an 8,000 lb. hammer at an inclination of 10 degrees.

View of Plant where piles are cast, and also view of pile driver.

Concrete Piles, 45 ft. long, 16 inches square.

COALING PIER OF THE LONDON & SOUTHWESTERN RAILROAD COMPANY.

Southampton, Eng. EUGENE W. T. FOWLER

Length, 355 feet. Width, 22 feet. *Moving load*, 18 tons.

RECREATION PIER AT ARCACHON SEASHORE.

Length of pier, 850 feet.

France.

PHOENIX WHARF AT NORTHAM, ENGLAND.

This wharf, originally constructed in masonry, was in a very bad state and in urgent need of repair. To allow the 40 ton crane to travel on railway tracks, an Armored Concrete floor was built on Concrete Piles in the Hennebique System.

JETTY AT WOOLSTON, ENGLAND.

Designed for a live load of 600 lbs. per square foot. Crane lifting 60 tons. Concrete piles 40 ft. long, braced together with Concrete Struts.

JETTY AT SOUTHAMPTON, ENGLAND.

Concrete Sheet Piles 40 feet long. Section, 8 x 16 inches. Piles driven by a two ton rammer, capped together by Concrete Beams.

COMPRESSOL PILLAR.

COMPRESSOL MACHINE.

HENNEBIQUE SYSTEM OFFICES.

FRANCE.

PARIS ..... 1 Rue Danton
LILLE ..... 18 Rue des Fleurs
LYON ..... 38 Boulevard de Brotteaux
NANCY ..... 166 Rue Jeanne D'Arc
NANTES ..... 17 Rue D'Alger
CHALONS S-MARNE ..... 9 Rue Pasteur
BORDEAUX ..... 1 Place Gabriel
GRANVILLE ..... 6 Boulevard d'Hauteserve
ROUEN ..... 37 Rue du Champ des Oiseaux
MARSEILLES ..... 6 Rue du Coq
PERPIGNAN ..... 15 Rue des Augustins
CLERMONT-FERRAND ..... 14 Rue de Riom
TOULOUSE ..... 49 Boulevard Lascrosses
BESANCON ..... 32 Rue Charles-Nodier
ALGIERS ..... 17 Avenue Dujonchay
TUNIS ..... 2 Rue d'Angleterre

ITALY

TORINO ..... 20 Corso Valentino
GENOA ..... 6 Via Maddoloni
MILAN ..... 12 Via Morigi
NAPLES ..... 50 Galleria Umberto
BOLOGNA ..... 4 Via Manzoni

GERMANY

COLOGNE ..... 5 Kaiser Wilhelm-Ring
DUSSELDORF ..... 31 Kronen Strasse
MUNICH ..... 6 Carl Strasse

ENGLAND

LONDON ..... 38 Victoria Street
MANCHESTER ..... 16 Grosvenor Chambers
SOUTHAMPTON ..... Maritime Chambers
NEWCASTLE-ON-TYNE ..... 18 Victoria Square

SWITZERLAND

LAUSANNE ..... Maison Villard

BELGIUM

BRUSSELS ..... 220 Chaussee de Ninove

SPAIN

MADRID ..... 5 Calle Serrano

PORTUGAL

LISBON ..... 4 Rue Palmyra

RUSSIA

SAINT PETERSBURG ..... 4 Zamiatine
EKATERINOSLAW ..... Perspective Catherine

DENMARK

COPENHAGEN ..... 53 Norre Farimagsgade

ALSACE

STRASSBURG ..... 12 Kuhn Gasse

GREECE

ATHENS ..... 5 Rue Zoodochos Pighis

EGYPT

CAIRO ..... 1 Rue Zaki

INDO-CHINA

SAIGON ..... 33 Rue Miche

ARGENTINE REPUBLIC

BUENOS AYRES ..... 181 Reconquista

SOUTH AFRICA

JOHANNESBURG ..... Sack Building

AUSTRIA HUNGARY

LEMBERG ..... 3 Rue Na Bloni
BUDA PESTH ..... 2 Trefort Utcza

MEXICO

MEXICO CITY ..... 408 Apartado